



**DNA Molecules and Polypeptides of *Pseudomonas syringae*  
Hrp Pathogenicity Island and Their Uses**

5                   This application claims benefit of U.S. Provisional Patent Application  
Serial Nos. 60/194,160, filed April 3, 2000, 60/224,604, filed August 11, 2000, and  
60/249,548, filed November 17, 2000, which are hereby incorporated by reference in  
their entirety.

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may have certain rights in this invention.

**Field of the Invention**

15                   The present invention relates to isolated DNA molecules  
corresponding to the open reading frames in the conserved effector loci and  
exchangeable effector loci of the *Pseudomonas syringae*, the isolated proteins  
encoded thereby, and their various uses.

**Background of the Invention**

20                   The plant pathogenic bacterium *Pseudomonas syringae* is noted for its  
diverse and host-specific interactions with plants (Hirano and Upper, 1990). A  
specific strain may be assigned to one of at least 40 pathovars based on its host range  
among different plant species and then further assigned to a race based on differential  
25                   interactions among cultivars of the host. In host plants the bacteria typically grow to  
high population levels in leaf intercellular spaces and then produce necrotic lesions.  
In nonhost plants or in host plants with race-specific resistance, the bacteria elicit the  
hypersensitive response (HR), a rapid, defense-associated programmed death of plant  
cells in contact with the pathogen (Alfano and Collmer, 1997). The ability to produce  
30                   either of these reactions in plants appears to be directed by *hrp* (HR and  
pathogenicity) and *hrc* (HR and conserved) genes that encode a type III protein  
secretion pathway and by *avr* (avirulence) and *hop* (Hrp-dependent outer protein)  
genes that encode effector proteins injected into plant cells by the pathway (Alfano  
and Collmer, 1997). These effectors may also betray the parasite to the HR-triggering

*R*-gene surveillance system of potential hosts (hence the *avr* designation), and plant breeding for resistance based on such gene-for-gene (*avr-R*) interactions may produce complex combinations of races and differential cultivars (Keen, 1990). *hrp/hrc* genes are probably universal among necrosis-causing gram-negative plant pathogens, and they have been sequenced in *P. syringae* pv. *syringae* (*Psy*) 61, *Erwinia amylovora* Ea321, *Xanthomonas campestris* pv. *vesicatoria* (*Xcv*) 85-10, and *Ralstonia solanacearum* GMI1000 (Alfano and Collmer, 1997). Based on their distinct gene arrangements and regulatory components, the *hrp/hrc* gene clusters of these four bacteria can be divided into two groups: I (*Pseudomonas* and *Erwinia*) and II (*Xanthomonas* and *Ralstonia*). The discrepancy between the distribution of these groups and the phylogeny of the bacteria provides some evidence that *hrp/hrc* gene clusters have been horizontally acquired and, therefore, may represent pathogenicity islands (Pais) (Alfano and Collmer, 1997).

Pais have been defined as gene clusters that (i) include many virulence genes, (ii) are selectively present in pathogenic strains, (iii) have different G+C content compared to host bacteria DNA, (iv) occupy large chromosomal regions, (v) are often flanked by direct repeats, (vi) are bordered by tRNA genes and/or cryptic mobile genetic elements, and (vii) are unstable (Hacker et al., 1997). Some Pais have inserted into different genomic locations in the same species (Wieler et al., 1997). Others reveal a mosaic structure indicative of multiple horizontal acquisitions (Hensel et al., 1999). Genes encoding type III secretion systems are present in Pais in animal pathogenic *Salmonella* spp. and *Pseudomonas aeruginosa* and on large plasmids in *Yersinia* and *Shigella* spp. Genes encoding effectors secreted by the pathway in these organisms are commonly linked to the pathway genes (Hueck, 1998), although a noteworthy exception is *sopE*, which is carried by a temperate phage without apparent linkage to SPI1 in certain isolates of *S. typhimurium* (Mirolid et al., 1999). Three *avr/hop* genes have already been shown to be linked to the *hrp/hrc* cluster in *P. syringae*: *avrE* and several other Hrp-regulated transcriptional units are linked to the *hrpR* border of the *hrp* cluster in *P. syringae* pv. *tomato* (*Pto*) DC3000 (Lorang and Keen, 1995); *avrPphE* is adjacent to *hrpY* (*hrpK*) in *Pseudomonas phaseolicola* (*Pph*) 1302A (Mansfield et al., 1994); and *hopPsyA* (*hrmA*) is adjacent to *hrpK* in *Psy* 61 (Heu and Hutcheson, 1993). Other *Pseudomonas avr* genes are located elsewhere in

the genome or on plasmids (Leach and White, 1996), including a plasmid-borne group of *avr* genes described as a Pai in *Pph* 1449B (Jackson et al., 1999).

Because Avr, Hop, Hrp, and Hrc proteins represent promising therapeutic treatments in both plants and animals, it would be desirable to identify other proteins encoded by the Pai's in pathogenic bacteria and identify uses for those proteins.

The present invention overcomes these deficiencies in the art.

### Summary of the Invention

One aspect of the present invention relates to isolated nucleic acid molecules (i) encoding proteins or polypeptides of *Pseudomonas* Conserved Effector Loci ("CEL") and Exchangeable Effector Loci ("EEL") genomic regions, (ii) nucleic acid molecules which hybridize thereto under stringent conditions, or (iii) nucleic acid molecules that include a nucleotide sequence which is complementary to the nucleic acid molecules of (i) and (ii). Expression vectors, host cells, and transgenic plants which include the DNA molecules of the present invention are also disclosed. Methods of making such host cells and transgenic plant are disclosed.

A further aspect of the present invention relates to isolated proteins or polypeptides encoded by the nucleic acid molecules of the present invention. Compositions which contain the proteins are also disclosed.

Yet another aspect of the present invention relates to methods of imparting disease resistance to a plant. According to one approach, this method is carried out by transforming a plant cell with a heterologous DNA molecule of the present invention and regenerating a transgenic plant from the transformed plant cell, wherein the transgenic plant expresses the heterologous DNA molecule under conditions effective to impart disease resistance. According to another approach, this method is carried out by treating a plant with a protein or polypeptide of the present invention under conditions effective to impart disease resistance to the treated plant.

A still further aspect of the present invention relates to a method of making a plant hypersusceptible to colonization by nonpathogenic bacteria. According to one approach, this method is carried out by transforming a plant cell with a heterologous DNA molecule of the present invention and regenerating a

transgenic plant from the transformed plant cell, wherein the transgenic plant expresses the heterologous DNA molecule under conditions effective to render the transgenic plant hypersusceptible to colonization by nonpathogenic bacteria.

According to an alternative approach, this method is carried out by treating a plant with a protein or polypeptide of the present invention under conditions effective to render the treated plant susceptible to colonization by nonpathogenic bacteria.

Another aspect of the present invention relates to a method of causing eukaryotic cell death by introducing into a eukaryotic cell a cytotoxic *Pseudomonas* protein, where the introducing is performed under conditions effective to cause cell death.

A further aspect of the present invention relates to a method of treating a cancerous condition by introducing a cytotoxic *Pseudomonas* protein into cancer cells of a patient under conditions effective to cause death of cancer cells, thereby treating the cancerous condition.

The benefits of the present invention result from three factors. First, there is substantial and growing evidence that phytopathogen effector proteins have evolved to elicit exquisite changes in eukaryote metabolism at extremely low levels, and at least some of these activities are potentially relevant to mammals and other organisms in addition to plants. For example, ORF5 in the *Psy* B728a EEL is similar to *Xanthomonas campestris* pv. *vesicatoria* AvrBsT, a phytopathogen protein that appears to have the same active site as its animal pathogen homolog YopJ, which inhibits mammalian MAPKK defense signaling (Orth et al., 2000). Second, the *P. syringae* CEL and EEL regions are enriched in effector protein genes, which makes these regions fertile targets for effector gene bioprospecting. Third, rapidly developing technologies for delivering genes and proteins into plant and animal cells improve the efficacy of protein-based therapies.

### Brief Description of the Drawings

Figure 1 is a diagram illustrating the conserved arrangement of *hrp/hrc* genes within the Hrp Pairs of *Psy* 61, *Psy* B728a, and *Pto* DC3000. Regions sequenced in B728a and DC3000 are indicated by lines beneath the strain 61 sequence. Known regulatory genes are shaded. Arrows indicate the direction of

transcription, with small boxes denoting the presence of a Hrp box. The triangle denotes the 3.6-kb insert with phage genes in the B728a *hrp/hrc* region.

Figures 2A-C show the EEL of *Pto* DC3000, *Psy* B728a, and *Psy* 61, the *tgt-queA*-tRNA<sup>Leu</sup> locus in *P. aeruginosa* (*Pa*), and EEL border sequences. Figure 2A is a diagram of the EELs of three *P. syringae* strains shown aligned by their *hrpK* sequences and are compared with the *tgt-queA*-tRNA<sup>Leu</sup> locus in *Pa* PA01. Arrows indicate the direction of transcription, with small boxes denoting the presence of a Hrp box. Shaded regions are conserved, striped regions denote mobile genetic elements, and open boxes denote genes that are completely dissimilar from each other. Figure 2B is an alignment of the sequences of the DC3000 (DC) (SEQ. ID. No. 85), B728a (B7) (SEQ. ID. No. 86), and 61 (SEQ. ID. No. 87) EELs at the border with tRNA<sup>Leu</sup>, with conserved nucleotides shown in upper case. Figure 2C is an alignment of the sequences of the DC3000 (DC) (SEQ. ID. No. 88), B728a (B7) (SEQ. ID. No. 89), and 61 (SEQ. ID. No. 90) EELs at the border with *hrpK*, with conserved nucleotides shown in upper case.

Figure 3 is a diagram illustrating the Hrp Pai CEL of *P. syringae*. The *Pto* DC3000 CEL is shown with the corresponding fragments of *Psy* B728a that were sequenced aligned below. The nucleotide identity of the sequenced fragments in coding regions ranged from 72% to 83%. Arrows indicate the direction of transcription, with small boxes denoting the presence of a Hrp box.

Figures 4A-E illustrate the plant interaction phenotypes of *Pto* mutants carrying deletions of the EEL (CUCPB5110) and CEL (CUCPB5115). Figure 14A is a graph illustrating growth in tomato of DC3000 and CUCPB5110 (mean and SD). Figure 14B is a graph illustrating growth in tomato of DC3000, CUCPB5115, and CUCPB5115(pCPP3016) (mean and SD). Figure 14C is an image showing HR collapse in tobacco leaf tissue 24 h after infiltration with 10<sup>7</sup> cfu/ml of DC3000 and CUCPB5115. Figure 14D is an image showing the absence of disease symptoms in tomato leaf 4 days after inoculation with 10<sup>4</sup> cfu/ml of CUCPB5115. Figure 14E is an image showing disease symptoms typical of wild-type in tomato leaf 4 days after inoculation with 10<sup>4</sup> cfu/ml of CUCPB5115(pCPP3016).

Figure 5 is an image of the immunoblot analysis showing AvrPto secretion by *Pto* DC3000 derivatives with deletions affecting the three major regions

of the Hrp Pai. Bacteria were grown in Hrp-inducing minimal medium at pH 5.5 and 22°C to an OD<sub>600</sub> of 0.35 and then separated into cell-bound (C) and supernatant (S) fractions by centrifugation. Proteins were then resolved by SDS-PAGE, blotted, and immunostained with antibodies against AvrPto and β-lactamase as described

5 (Manceau and Harvais, 1997), except that supernatant fractions were concentrated 3-fold relative to cell-bound fractions before loading. *Pto* DC3000, CUCPB5115 (CEL deletion), CUCPB5114 (*hrp/hrc* deletion), and CUCPB5110 (EEL deletion) all carried pCPP2318, which expresses β-lactamase without a signal peptide as a cytoplasmic marker.

10 Figures 6A-B illustrate, enlarged as compared to Figure 1, the organization of the *shcA* and *hopPsyA* operon in the EEL of the Hrp Pai of *Psy* 61. In Figure 6A, the *shcA* and *hopPsyA* are depicted as white boxes. At the border of the Hrp Pai are the *tRNA<sup>Leu</sup>* and *queA* genes depicted as gray boxes. A 5' truncated *hrpK* gene is represented as a hatched box. The arrows indicate the predicted direction of  
15 transcription and the black box denotes the presence of a putative HrpL-dependent promoter upstream of *shcA*. Figure 6B illustrates schematically the construction of the deletion mutation in the *shcA* ORF marker-exchanged into *Psy* 61. Black bars depict regions that were amplified along with added restriction enzyme sites and each are aligned with the corresponding DNA region represented in Figure 6A. The striped  
20 box depicts the *nptII* cassette that lacks transcriptional and translational terminators used in making the functionally nonpolar *shcA* *Psy* 61 mutant. *EcoRI*, E; *EcoRV*, V; *XbaI*, X; and *XhoI*, Xh.

Figure 7 is an image of an immunoblot showing that *shcA* encodes a protein product. pLV9 is a derivative of pFLAG-CTC in which the *shcA* ORF is  
25 cloned and fused to the FLAG epitope and translation is directed by a vector ribosome binding site (RBS). pLV26 contains an amplified product containing the *shcA* coding region and its native RBS site. Cultures of *E. coli* DH5α carrying either pFLAG-CTC (Control), pLV9, or pLV26 were grown to an OD<sub>600</sub> of 0.8 and then 100 μl aliquots were taken, centrifuged, resuspended in SDS-PAGE buffer, and then subjected to  
30 SDS-PAGE and immunoblot analysis with anti-FLAG antibodies and secondary antibodies conjugated with alkaline phosphatase.

Figure 8 is an image of an immunoblot showing that *Psy* 61 *shcA* mutant UNLV102 does not secrete HopPsyA and *shcA* provided *in trans* complements this defect. *Psy* 61 cultures were grown at 22°C in *hrp*-derepressing medium and separated into cell-bound (C) and supernatant fractions (S). The cell-bound fractions were concentrated 13.4-fold and the supernatant fractions were concentrated 100-fold relative to the initial culture volumes. The samples were subjected to SDS-PAGE and immunoblot analysis, and HopPsyA and  $\beta$ -lactamase (Bla) were detected with either anti-HopPsyA or anti- $\beta$ -lactamase antibodies followed by secondary antibodies conjugated to alkaline phosphatase as described in the experimental procedures. The image of the immunoblot was captured using the Bio-Rad Gel Doc 2000 UV fluorescent gel documentation system with the accompanying Quantity 1 software.

Figure 9 is an image of an immunoblot showing that *shcA* is required for the type III secretion of HopPsyA, but not secretion of HrpZ. *P. fluorescens* 55 cultures were grown in *hrp*-derepressing medium and separated into cell-bound (C) and supernatant (S) fractions. The cell-bound fractions were concentrated 13.4-fold and the supernatant fractions were concentrated 100-fold relative to the initial culture volumes. The samples were subjected to SDS-PAGE and immunoblot analysis, and HopPsyA and HrpZ were detected with either anti-HopPsyA or anti-HrpZ antibodies followed by secondary antibodies conjugated to alkaline phosphatase as described in experimental procedures. The image of the immunoblot was captured using the Bio-Rad Gel Doc 2000 UV fluorescent gel documentation system with the accompanying Quantity 1 software.

Figure 10 is a series of four images of tobacco leaves showing that *P. fluorescens* 55 carrying a pHIR11 derivative with a functionally nonpolar *shcA* mutation is impaired in its ability to translocate HopPsyA into plant cells. *P. fluorescens* 55 cultures were grown overnight in King's B and suspended in 5 mM MES pH 5.6 to an OD<sub>600</sub> of 1.0, and infiltrated into tobacco leaf panels. Because the pHIR11-induced HR is due to the translocation of HopPsyA inside plant cells, a reduced HR indicates that HopPsyA is not delivered well enough to induce a typical HR. The leaf panels were photographed with incident light 24 hours later.

Figure 11 is an image of an immunoblot showing that ShcA binds to HopPsyA. Soluble protein samples from sonicated cultures (Sonicate) of *Psy* 61 *shcA* mutant UNLV102 carrying pLN1 (HopPsyA) or pLN2 (ShcA-FLAG, HopPsyA) were mixed with anti-FLAG M2 affinity gel (Gel). The gel was washed (Wash) with TBS buffer, mixed with SDS-PAGE buffer, and subjected to SDS-PAGE and immunoblot analysis along with the sonicate and wash samples. HopPsyA and ShcA-FLAG were detected with anti-HopPsyA or anti-FLAG antibodies followed by secondary antibodies conjugated to alkaline phosphatase as described in experimental procedures.

Figure 12 is a diagram illustrating the spindle checkpoint in *S. cerevisiae*. The spindle checkpoint is activated by a signal emitted from the kinetochores when there are abnormalities with the microtubules. This signal is somehow received by the spindle checkpoint components, which respond in a variety of ways. Mad2 is thought to bind to Cdc20 at the APC inhibiting its ubiquitin ligase activity. In the absence of Mad2 (and presumably damage to the spindle), the APC is active and it marks Pds1 and other inhibitors of anaphase for degradation via the ubiquitin proteolysis pathway; anaphase ensues.

Figures 13A-B illustrate the effects of transgenically expressed HopPsyA on *Nicotiana tabacum* cv. Xanthi, *Nicotiana benthamiana*, and *Arabidopsis thaliana*. Figure 13A shows *N. tabacum* cv. Xanthi and *N. benthamiana* leaves infiltrated with *Agrobacterium tumefaciens* GV3101 with or without pTA7002::*hopPsyA*. Figure 13B illustrates *Arabidopsis thaliana* Col-1 infiltrated with *A. tumefaciens* +/- pTA7002::*hopPsyA*. For all plants shown in Figures 13A-B, 48 h after *Agrobacterium* infiltration, plants were sprayed with the glucocorticoid dexamethasone (DEX). Images were collected 24 h after DEX treatment. *A.t.* = *Agrobacterium tumefaciens*; pA = pTA7002::*hopPsyA*.

Figure 14 is an image of an SDS-PAGE which shows the distribution of HopPsyA and  $\beta$ -lactamase in cultures of *Psy* 61 (pCPP2318) or a *hrp* mutant, *Psy* 61-2089 (pCPP2318). Bacterial cultures were grown at 22°C in *hrp*-depressing medium and separated into cell-bound (C) and supernatant fractions (S). The cell-bound fractions were concentrated 13.4 fold, and the supernatant fractions were concentrated 100 fold relative to initial culture volumes. The samples were subjected

to SDS-PAGE and immunoblot analysis and HopPsyA and  $\beta$ -lactamase were detected with either anti- HopPsyA or anti- $\beta$ -lactamase antibodies followed by secondary antibodies conjugated to alkaline phosphatase. *Pss* wild-type = *Pseudomonas syringae* pv. *syringae* 61 (pCPP2318); *Pss hrcC* = *Pseudomonas syringae* pv. *syringae* 61-2089 (pCPP2318).

Figure 15 is a graph illustrating the ability of wild-type *Pseudomonas syringae* pv. *syringae* and a *hopPsyA* mutant to multiply in bean leaves. Values represent the average plate counts from crushed plant leaves of two independent inoculations. Wild-type (●), *Pseudomonas syringae* pv. *syringae* 61; *hopPsyA* mutant (○), *Pseudomonas syringae* pv. *syringae* 61-2070.

Figures 16A-B illustrate the interaction of HopPsyA and Mad2 in a yeast two-hybrid assay. Figure 16A illustrates cultures of yeast EGY48 strains containing either pLV24 (pEG202::'*hopPsyA*') and pJG4-5 (fish-vector), pLV24 and pLV116 (pJG4-5::'*mad2*'), or pEG202 (bait vector) and pLV116 on medium containing 5-bromo-4-chloro-3-indolyl- $\beta$ -D-galactopyranoside (Xgal) to check for  $\beta$ -galactosidase activity with either glucose (Glc) or galactose (Gal).  $\beta$ -galactosidase activity was indicated only in the presence of both HopPsyA and Mad2. Figure 16B illustrates cultures of the same yeast strains on minimal medium leucine dropout plates with either Glc or Gal sugars. 1 = EGY48 (pLV24, pJG4-5); 2 = EGY48 (pLV24, pLV116); 3 = EGY48 (pEG202, pLV116).

### Detailed Description of the Invention

A DNA molecule which contains the CEL of *Pseudomonas syringae* pv. tomato DC3000 has a nucleotide sequence (SEQ. ID. No. 1) as follows:

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25 ggtaccgggc tctgtgacgc agagcggtcac gcaaggcatt ccactggagc gtgaggaacg 60
   ataatcctga cgacaactat cgtgcgcagc tccgcgctcg catgccgttc tggacgctct 120
   gcgtcctgtc ttgagagggtg cgccaagcgc aaagcacggt aagtatcagg gaggggtgta 180
   taggagggtt gcaaggcggtg aggtgttcac atcaaggcag tgttcacgaa cccgtcttgc 240
30 ctgggctcat gaacacgttc ggcttacgcg gtcagtgcac ttctcgcctc aaatggtcca 300
   gccctgccag catcaactca tgccgggtgga tgctgtccag gctggcgtag gaaccgggtt 360
   tttcgttgac cgcgtgccac accacaaagt cgcgtcgtac gtccagaaac aggaagtagt 420
   gattgaaacg ctctgactcc ataaaacgct gttgcagtgc atcacgcagt tgatcgggac 480
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40 ttcgctcccc ggagcagtga cggcctgctt tctttggcca ttttagatat ctgcggctgg 900

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	catggaaatt	cccgcgtcgt	ttaacgatga	ttttcctctg	tggttcaaga	cgtgatgcgg	26940
45	ttccctttag	ggtttgact	aatatcaatg	cgattcttgt	aaaaatcgac	tcgtgagtgc	27000
	cgccgatggc	aaaggtaacg	ggatggggcg	cgagtttttg	gtaacgttgc	cgttgttgca	27060
	gggttgaatt	tgttgggtga	cgttaaaacg	aaggaatgta	tgcttaaaaa	atgcctgcta	27120
	ctgggtatata	caatgtcact	tggcggctgc	tggagcctga	tgattcatct	ggacggcgag	27180
	cgttgcatct	atcccggcac	tcgccaaggt	tgggcgtggg	gaacccataa	cggagggcag	27240
50	agttggccca	tacttataga	cgtgccgttt	tccctcgcgt	tggacacact	gctgctgccc	27300
	tacgacctca	cgccttttct	gcccgaataa	cttggcggtg	atgaccgcaa	atgtcagttc	27360
	agtggaaggat	tgaacgtgct	cggttgatcc	atatttttac	tgcgacagaa	gagtgcggcc	27420
	ccgacgcttt	tggagagcac	accagggatt	caaaccgcgc	ttaaaagctt	tatatgcgtg	27480
	gcatgcacct	cgtcaactgc	ctgaaaagccg	caacgtaagt	aaaattttgc	tccgctcgga	27540
55	gtatcagtga	acaggcgcac	ggcgaaaaat	tccctgcgcg	catgctccac	aagtcgattc	27600
	accagagtct	ttccaaggcc	ttgacctctt	gatgcgcttg	cgacgtataa	ccgtcgtagc	27660
	ctgcccatat	caccccgggc	atgcggatca	cgcgaaaagg	ctccgatacc	tgccagagcg	27720
	ccgtccagaa	gtacgacct	gaggcattca	cccttggcct	cgaatcgatt	ctttccggac	27780
	ctccactcct	cgatcaagcg	ggtaagaaac	ctgaagccct	ctgctactgc	ctcttgctcc	27840
60	aggatcagaa	cctgacaagg	caattcagta	atgatctgga	cttctacctg	tttcatctaa	27900
	tgacctcatc	cacagtggtc	ctgcgctggc	gaaaacacga	gcaggtctgg	acagaaatgc	27960
	tatgcaacag	caaaggctgc	aaccagtgca	caccaccaga	accgggttcg	acagttaagc	28020
	tgatatcatt	caagcacctg	caagccgagt	agaagcacat	gaaccgtcgc	aagaaaatac	28080
	agcaactggt	aaaggctcat	gccaagaaag	ccagcgctaa	actggcaccc	gcaaacaaat	28140
65	ccagctacgt	gagcaaggct	gatcgggtga	agctggcgcc	agagtcgggt	aacgacccga	28200

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5  tcagttccgt cgaggactga acagcgacgt ttacgcgcca ccggtatggt caggctgttc 28260
   attccgatgg agcgatttgc aaggagcctg ttcaacagct cacttacttc gcaaacgagt 28320
   actcaccgcc ctgctccagc gcctggcgat acgcaggtct ttcttgccat cgttgtacct 28380
   aggcgtgcaag gttaggatgc ggctgcagca ttccctgcat tttggcgaaat tcgccaatga 28440
   agctcatctg aatatccgcg cactcaatt cgtcgcccag cagataaggc gtcagcccca 28500
   gagcttcatt cagatagccc agatagttgg ccagttcaga gtgaatgcgc ggatgcaaaag 28560
   gcgcgcccgc gtcacccagg cgaccgacgt acaggttgag catcagcggc agaatggccg 28620
   aaccttcggc gaagtgcagc cattgtacgt actcatcgta ggtggcgctg gcaggatccg 28680
   gttgcaggcg gccgtcgcca tgacggcgga tcaggtaatc gacgatggcg ccagactcga 28740
10  taaccacatg gggaccgtct tcgatcaccg gggattttgcc cagcggatga atggccttca 28800
   gctcaggcgg cgcgaggttg gttttcgggt cgcgctggta gcgttttata tcgtacggca 28860
   ggccaagtcc ttcgagtaac cacagaatgc gctgcgaacg tgagttgttc aggtgggtgga 28920
   caataatcat gtgggtctcc gctgggtgag agtgggatgt ctagaaaaag actgctgggc 28980
   cgccgtagag tgccgtgaat cgaatgtcct ctggcgacct cagacgcgtc tgcggcgca 29040
15  gagcgtgccc gactcaccgc gaagctgacg ctccactgcc gctttatcga ttaccgacca 29100
   aacgcgcgatt atcttgccat cgctgaatgc gtgaacaca ttttcggaaa aggtgatgcg 29160
   ccgtccctgt gtgtcctgcc ccagaaatcg accctgtggc gagcagttga agaccagccg 29220
   ggcagcgacc tgtggtgctt caacgaccag caaatcgatc ttgaaacgca agtcggggat 29280
   aatcctgacg tcgtttttcca gcattgtttt gtagccggaa aggcctgatca gctcaccgtt 29340
20  gtaatgcaca ttgtcatcga cgaagttgcc caactgggtg caactacggc cattcagaca 29400
   ggcgatgtaa gcccgatagt gatcggtcag gttcatggcg cgccctcctt caggtgctca 29460
   aagcagtcac tgtcaatcat ccagataacc cgcacagttt taacagagtc atagggaact 29520
   cgtgcggccg acatcgccct aagcctcaca tctatgtact ggcgcgacgc tggtttcaag 29580
   cgaaggactt cagattcatg tcttcaagta gcactacagc agcggtgac acgcaaggc 29640
25  ggcaaaacgc ctgcgctaac cgactgattt tcatctccgt acttgtggca accatgggcg 29700
   cgctcgcggt tggttatgac accggtatta tcgncggcgc attgcccttc atgacgctgc 29760
   cgcccgatca ggcgggctg ggtttgaatg cctacagcga agggatgatc acggcttcgc 29820
   tgatcgctcg tgcagccttc ggctcactgg ccagtggtta tatttccgac cgtttcggac 29880
   gacgcctgac cctgcgcctc ctgtcggtgc tgttcacgc gggcgcgctg ggtacggcca 29940
30  ttgcgcgctc cattccgttc atggctgcgc cgcgcttctt gctgggtatc gcgggtgggtg 30000
   gcggctcggc gacggtgcgc gtgttcattg ccgaaatcgc cggccctcgc cgtcgtgcgc 30060
   ggctgggtcag ccgcaacgaa ctgatgatgc tcagcgcca gttgctcgcc tatgtgctca 30120
   gcgcggtcat ggccgcgctg ctgcacacgc cgggcatctg gcgctatatg ctggcgatcg 30180
   cgatgggtgcc gggggtgttg ctgctgatcg gcaccttctt cgtacctcct tcgccngct 30240
35  ggctggcgct caaaggccgt tttgacgaag ctcaggatgt gctggagcaa ctgcccagca 30300
   acaaggacga tgcgcancgt gaagtggacg aaatgaaagc tcatgacgag caggcgcgca 30360
   atcgt                                     30365

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40 Several undefined nucleotides exist in SEQ. ID. No. 1, however these appear to be present in intergenic regions. The CEL of *Pseudomonas syringae* pv. tomato DC3000 contains a number of open reading frames (ORFs). Two of the products encoded by the CEL are HrpW and AvrE, both of which are known. An additional 10 products are produced by ORF1-10, respectively, as shown in Figure 3. The nucleotide

45 sequences for a number of these ORFs and their encoded protein or polypeptide products are provided below.

The DNA molecule of *ORF3* from the *Pseudomonas syringae* pv. tomato DC3000 CEL has a nucleotide sequence (SEQ. ID. No. 2) as follows:

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50  atgatcagtt cgcggatcgg cggggccggt ggcgtcaaac tcagccgggt aaaccagcag 60
   caccgatactg ttcccgccca gacagctcac ccaaatgcag tcaactgcagg catgaatccg 120
   ccgctgactc ccgatcagtc agggctcacac gcgacagaaa gctcgtctgc cggcgcggcg 180
   cggctgaatg tcgcggctcg acacacacag cttttgcagg ctttcaaggc tgagcatggg 240
   acggctccgg tcagcggcgc gccgatgatc agttcgcgtg ctgcgttggt gatcggtagt 300
55  ctgctgcagg ccagccttt gccttttgaa gtcattggccg agaaattgtc tcttgagcgc 360
   tatcaactga agcagtttca gggctcggac ttgcagcagc ggctggaaaa attcggccag 420

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ccgggtcaga taccggataa agccgaggtc gggcaactga tcaagggttt tgctcagtcg 480  
gtcgctgata aactggagca ctttcaactg atgcatgacg cttcgcccg c aacggtaggc 540  
cagcatgcaa aagcggacaa ggcgacgctt gccgtcagtc agactgccct tggcgaatac 600  
gccggtcgtg caagcaaggc aatcggcgaa ggcctgagca acagcatcgc gtcgctggat 660  
5 gaggacatca gtgcgctgga tctcactctg caagatgccg aacagggcaa caaggagtct 720  
ctgcacgctg acaggcaggc gctggctgac gccaaaacca ccctggtagg tttgcacgcc 780  
gatttcgtca agtcgcccga ggccaagcgc cttgcttcgg tcgccgcaca tacgcaactg 840  
gacaacgctg tcagcgatct cgtcactgcc cgtaacacgg tgggtggctg gaaagggtgca 900  
gggccgattg tcgcccgtgc ggttccgcag ttcttgtctt caatgacaca cttgggttat 960  
10 gtgcgtttgt ccaccagcga caagctcgga gacacgattc ccgagaccag cagcgacgcc 1020  
aacatgctca aggtctcgat aatcgggatg gtggcgggca ttgctcacga gacgggtcaac 1080  
agcgtggtca agccgatgtt tcaggccgcc ttgcagaaga ctggcctcaa cgaacgcctg 1140  
aacatgggtg caatgaaggc tgtggatacc aatacggtta ttctgaccc cttcgagctg 1200  
aaaagcgaac acggtgagct ggtcaaaaa acgcccagag aagtgcgtca ggacaaggcg 1260  
15 ttcgtgaaaa gtgaacgcgc gctgctgaac cagaagaagg ttcagggttc gtccacccat 1320  
ccggtaggtg agctgatggc ttacagtgcc ttcggtggtt ctcaggctgt gcgccagatg 1380  
ctcaacgatg ttcaccagat caatgggcag acgctgagtg caagagctct ggcacccggt 1440  
tttggcgggg cggtgtctgc cagttcgcaa acgctgctgc aattgaagtc gaattatgtc 1500  
gacccgcaag ggcgcaaaat tccggtattt accccggacc gcgccgagag cgaatctgaaa 1560  
20 aaggacctgc tcaaaggtat ggacctgcgc gagccgtcgg tacgaccac gttctacagc 1620  
aaggtctttt cggttattca gagttctgca ctgacctcgg cactgccgcc tgtgaccgct 1680  
caggtctgaag gcgcaagtgg cagctcagt gcgggggcta ttttgcgcaa catggccctg 1740  
gcagcgacgg gttcgggtgc ctatctgtcc acgttgtaca ccaaccagtc ggttaccgca 1800  
25 gaagccaagg cgttgaaagc ggcaggcatg ggcggtgcaa cacctatgct ggaccgtacc 1860  
gagacgcttt ga 1872

The protein or polypeptide encoded by *Pto* DC3000 CEL *ORF3* has an amino acid sequence (SEQ. ID. No. 3) as follows:

30 Met Ile Ser Ser Arg Ile Gly Gly Ala Gly Gly Val Lys Leu Ser Arg  
1 5 10 15  
35 Val Asn Gln Gln His Asp Thr Val Pro Ala Gln Thr Ala His Pro Asn  
20 25 30  
Ala Val Thr Ala Gly Met Asn Pro Pro Leu Thr Pro Asp Gln Ser Gly  
35 40 45  
40 Ser His Ala Thr Glu Ser Ser Ser Ala Gly Ala Ala Arg Leu Asn Val  
50 55 60  
Ala Ala Arg His Thr Gln Leu Leu Gln Ala Phe Lys Ala Glu His Gly  
65 70 75 80  
45 Thr Ala Pro Val Ser Gly Ala Pro Met Ile Ser Ser Arg Ala Ala Leu  
85 90 95  
50 Leu Ile Gly Ser Leu Leu Gln Ala Glu Pro Leu Pro Phe Glu Val Met  
100 105 110  
Ala Glu Lys Leu Ser Pro Glu Arg Tyr Gln Leu Lys Gln Phe Gln Gly  
115 120 125  
55 Ser Asp Leu Gln Gln Arg Leu Glu Lys Phe Ala Gln Pro Gly Gln Ile  
130 135 140  
Pro Asp Lys Ala Glu Val Gly Gln Leu Ile Lys Gly Phe Ala Gln Ser  
145 150 155 160  
60 Val Ala Asp Gln Leu Glu His Phe Gln Leu Met His Asp Ala Ser Pro  
165 170 175

	Ala Thr Val Gly Gln His Ala Lys Ala Asp Lys Ala Thr Leu Ala Val	180	185	190
5	Ser Gln Thr Ala Leu Gly Glu Tyr Ala Gly Arg Ala Ser Lys Ala Ile	195	200	205
	Gly Glu Gly Leu Ser Asn Ser Ile Ala Ser Leu Asp Glu His Ile Ser	210	215	220
10	Ala Leu Asp Leu Thr Leu Gln Asp Ala Glu Gln Gly Asn Lys Glu Ser	225	230	235
	Leu His Ala Asp Arg Gln Ala Leu Val Asp Ala Lys Thr Thr Leu Val	245	250	255
15	Gly Leu His Ala Asp Phe Val Lys Ser Pro Glu Ala Lys Arg Leu Ala	260	265	270
20	Ser Val Ala Ala His Thr Gln Leu Asp Asn Val Val Ser Asp Leu Val	275	280	285
	Thr Ala Arg Asn Thr Val Gly Gly Trp Lys Gly Ala Gly Pro Ile Val	290	295	300
25	Ala Ala Ala Val Pro Gln Phe Leu Ser Ser Met Thr His Leu Gly Tyr	305	310	315
	Val Arg Leu Ser Thr Ser Asp Lys Leu Arg Asp Thr Ile Pro Glu Thr	325	330	335
30	Ser Ser Asp Ala Asn Met Leu Lys Ala Ser Ile Ile Gly Met Val Ala	340	345	350
35	Gly Ile Ala His Glu Thr Val Asn Ser Val Val Lys Pro Met Phe Gln	355	360	365
	Ala Ala Leu Gln Lys Thr Gly Leu Asn Glu Arg Leu Asn Met Val Pro	370	375	380
40	Met Lys Ala Val Asp Thr Asn Thr Val Ile Pro Asp Pro Phe Glu Leu	385	390	395
	Lys Ser Glu His Gly Glu Leu Val Lys Lys Thr Pro Glu Glu Val Ala	405	410	415
45	Gln Asp Lys Ala Phe Val Lys Ser Glu Arg Ala Leu Leu Asn Gln Lys	420	425	430
50	Lys Val Gln Gly Ser Ser Thr His Pro Val Gly Glu Leu Met Ala Tyr	435	440	445
	Ser Ala Phe Gly Gly Ser Gln Ala Val Arg Gln Met Leu Asn Asp Val	450	455	460
55	His Gln Ile Asn Gly Gln Thr Leu Ser Ala Arg Ala Leu Ala Ser Gly	465	470	475
	Phe Gly Gly Ala Val Ser Ala Ser Ser Gln Thr Leu Leu Gln Leu Lys	485	490	495
60	Ser Asn Tyr Val Asp Pro Gln Gly Arg Lys Ile Pro Val Phe Thr Pro	500	505	510
65	Asp Arg Ala Glu Ser Asp Leu Lys Lys Asp Leu Leu Lys Gly Met Asp	515	520	525

Leu Arg Glu Pro Ser Val Arg Thr Thr Phe Tyr Ser Lys Ala Leu Ser  
530 535 540

5 Gly Ile Gln Ser Ser Ala Leu Thr Ser Ala Leu Pro Pro Val Thr Ala  
545 550 555 560

Gln Ala Glu Gly Ala Ser Gly Thr Leu Ser Ala Gly Ala Ile Leu Arg  
565 570 575

10 Asn Met Ala Leu Ala Ala Thr Gly Ser Val Ser Tyr Leu Ser Thr Leu  
580 585 590

15 Tyr Thr Asn Gln Ser Val Thr Ala Glu Ala Lys Ala Leu Lys Ala Ala  
595 600 605

Gly Met Gly Gly Ala Thr Pro Met Leu Asp Arg Thr Glu Thr Leu  
610 615 620

20

The DNA molecule of *ORF4* from the *Pseudomonas syringae* pv.  
tomato DC3000 CEL has a nucleotide sequence (SEQ. ID. No. 4) as follows:

25 atgaccaaca atgaccagta ccacaccctt atcaacgaaa tctgcgcact cagcctgatt 60  
tccacacctg aacgttttcta tgaatctgcc aatttcaaaa tcagcgaagt ggacttcacc 120  
ctgcagtttc aggaccgcga cgaaggccgt gccgttctga tctacggtga catgggcgcg 180  
ttgcccgcgc gcggccgtga gagcgcgttg ctggcgttga tggacatcaa ctttcacatg 240  
ttcgcgggcgc cccacagccc ggcattttcc tttaatgcgc agaccggtcg tgtgctgctg 300  
atgggctctg tggcccttga acgagcctct gccgaaggcg tgctgttggt gatgaagtcg 360  
30 ttttccgacc tggccaaaga gtggcgcgag catggattca tggggcaggc cacaactgca 420  
ggctcctcga cggaccaacc tggtgcccga gcagccaaac gcgagagcct ttcggctcct 480  
gggagattcc aatga 495

35 The protein or polypeptide encoded by *Pto* DC3000 CEL *ORF4* has an amino acid  
sequence (SEQ. ID. No. 5) as follows:

40 Met Thr Asn Asn Asp Gln Tyr His Thr Leu Ile Asn Glu Ile Cys Ala  
1 5 10 15

Leu Ser Leu Ile Ser Thr Pro Glu Arg Phe Tyr Glu Ser Ala Asn Phe  
20 25 30

45 Lys Ile Ser Glu Val Asp Phe Thr Leu Gln Phe Gln Asp Arg Asp Glu  
35 40 45

Gly Arg Ala Val Leu Ile Tyr Gly Asp Met Gly Ala Leu Pro Ala Arg  
50 55 60

50 Gly Arg Glu Ser Ala Leu Leu Ala Leu Met Asp Ile Asn Phe His Met  
65 70 75 80

Phe Ala Gly Ala His Ser Pro Ala Phe Ser Phe Asn Ala Gln Thr Gly  
85 90 95

55 Arg Val Leu Leu Met Gly Ser Val Ala Leu Glu Arg Ala Ser Ala Glu  
100 105 110

60 Gly Val Leu Leu Leu Met Lys Ser Phe Ser Asp Leu Ala Lys Glu Trp  
115 120 125

Arg Glu His Gly Phe Met Gly Gln Ala Thr Thr Ala Gly Ser Ser Thr  
130 135 140

5 Asp Gln Pro Val Ala Pro Ala Ala Lys Arg Glu Ser Leu Ser Ala Pro  
145 150 155 160

Gly Arg Phe Gln

10

The DNA molecule of *ORF5* from the *Pseudomonas syringae* pv.  
tomato DC3000 CEL has a nucleotide sequence (SEQ. ID. No. 6) as follows:

15 atgcacatca accgacgcgt ccaacaaccg cctgtgactg cgacggatag ctttcggaca 60  
gcgtccgacg cgtctcttgc ctccagctct gtgcgatctg tcagctccga tcagcaacgc 120  
gagataaatg cgattgccga ttacctgaca gatcatgtgt tcgctgcgca taaactgccg 180  
ccggccgatt cggctgatgg ccaagctgca gttgacgtac acaatgcgca gatcactgcg 240  
ctgatcgaga cgcgcgccag ccgcctgcac ttcgaagggg aaaccccgcc aaccatcgcc 300  
20 gacaccttcg ccaaggcgga aaagctcgac cgattggcga cgactacatc aggcgcgttg 360  
cgggcgacgc cctttgccat ggctcgttg cttcagtaca tgcagcctgc gatcaacaag 420  
ggcgattggc tgccggctcc gctcaaaccg ctgacccgcg tcatttccgg agcgcgtgtc 480  
ggcgccatgg accaggtggg caccaagatg atggaccgcg cgacgggtga tctgcattac 540  
ctgagcgcct cgccggacag gctccacgat gcgatggcgg cttcggtgaa gcgccactcg 600  
25 ccaagccttg ctgcagaggt tctggacacg ggggttgagg ttcagacgta ctcgggcgcg 660  
aacgcggtac gtaccgtatt ggctccggca ctggcgcca gaccgcctg gcagggtgct 720  
gtggaccttg gtgtatcgat ggcggtgggt ctggctgcca acgcaggctt tggcaaccgc 780  
ctgctcagtg tgcagtcgcg tgatcaccag cgtggcggtg cattagtgtc cggtttgaag 840  
gataaagagc ccaaggctca actgagcgaa gaaaacgact ggctcgaggc ttataaagca 900  
30 atcaaactcg ccagctactc ggggtgcggc ctcaacgctg gcaagcggat ggccgggtctg 960  
ccactggata tggcgaccga cgcaatgggt gcggttaagaa gcctggtgtc agcgtccagc 1020  
ctgacccaaa acggctctgc cctggcggtt ggctttgcag gggtaggcaa gttgcaggag 1080  
atggcgacga aaaatatcac cgaccgcggc accaaggccg cggtcagtca gttgaccaac 1140  
ctggcaggtt cggcagccgt tttcgcaggc tggaccacgg ccgcgctgac aaccgatccc 1200  
35 gcggtgaaaa aagccgagtc gttcatacag gacacggtga aatcgactgc atccagtacc 1260  
acaggctacg tagccgacca gaccgtcaaa ctggcgaaaga ccgtcaaaga catgggcggg 1320  
gaggcgatca cccataccgg cgccagcttg cgcaatacgg tcaataacct gcgtcaacgc 1380  
ccggctcgtg aagctgatat agaagagggg ggcacggcgg cttctccaag tgaaataacc 1440  
40 tttcggccta tgcggtcgta a 1461

The protein or polypeptide encoded by *Pto* DC3000 CEL *ORF5*, now known as  
HopPtoA, has an amino acid sequence (SEQ. ID. No. 7) as follows:

45 Met His Ile Asn Arg Arg Val Gln Gln Pro Pro Val Thr Ala Thr Asp  
1 5 10 15

Ser Phe Arg Thr Ala Ser Asp Ala Ser Leu Ala Ser Ser Ser Val Arg  
20 25 30

50 Ser Val Ser Ser Asp Gln Gln Arg Glu Ile Asn Ala Ile Ala Asp Tyr  
35 40 45

55 Leu Thr Asp His Val Phe Ala Ala His Lys Leu Pro Pro Ala Asp Ser  
50 55 60

Ala Asp Gly Gln Ala Ala Val Asp Val His Asn Ala Gln Ile Thr Ala  
65 70 75 80

	Leu	Ile	Glu	Thr	Arg	Ala	Ser	Arg	Leu	His	Phe	Glu	Gly	Glu	Thr	Pro
					85					90					95	
5	Ala	Thr	Ile	Ala	Asp	Thr	Phe	Ala	Lys	Ala	Glu	Lys	Leu	Asp	Arg	Leu
				100					105					110		
	Ala	Thr	Thr	Thr	Ser	Gly	Ala	Leu	Arg	Ala	Thr	Pro	Phe	Ala	Met	Ala
				115				120					125			
10	Ser	Leu	Leu	Gln	Tyr	Met	Gln	Pro	Ala	Ile	Asn	Lys	Gly	Asp	Trp	Leu
		130					135					140				
	Pro	Ala	Pro	Leu	Lys	Pro	Leu	Thr	Pro	Leu	Ile	Ser	Gly	Ala	Leu	Ser
		145				150					155					160
15	Gly	Ala	Met	Asp	Gln	Val	Gly	Thr	Lys	Met	Met	Asp	Arg	Ala	Thr	Gly
					165					170					175	
	Asp	Leu	His	Tyr	Leu	Ser	Ala	Ser	Pro	Asp	Arg	Leu	His	Asp	Ala	Met
				180					185					190		
	Ala	Ala	Ser	Val	Lys	Arg	His	Ser	Pro	Ser	Leu	Ala	Arg	Gln	Val	Leu
			195					200					205			
25	Asp	Thr	Gly	Val	Ala	Val	Gln	Thr	Tyr	Ser	Ala	Arg	Asn	Ala	Val	Arg
		210					215					220				
	Thr	Val	Leu	Ala	Pro	Ala	Leu	Ala	Ser	Arg	Pro	Ala	Val	Gln	Gly	Ala
		225				230					235					240
30	Val	Asp	Leu	Gly	Val	Ser	Met	Ala	Gly	Gly	Leu	Ala	Ala	Asn	Ala	Gly
					245					250					255	
	Phe	Gly	Asn	Arg	Leu	Leu	Ser	Val	Gln	Ser	Arg	Asp	His	Gln	Arg	Gly
				260					265					270		
	Gly	Ala	Leu	Val	Leu	Gly	Leu	Lys	Asp	Lys	Glu	Pro	Lys	Ala	Gln	Leu
			275					280					285			
40	Ser	Glu	Glu	Asn	Asp	Trp	Leu	Glu	Ala	Tyr	Lys	Ala	Ile	Lys	Ser	Ala
		290					295					300				
	Ser	Tyr	Ser	Gly	Ala	Ala	Leu	Asn	Ala	Gly	Lys	Arg	Met	Ala	Gly	Leu
		305				310					315					320
45	Pro	Leu	Asp	Met	Ala	Thr	Asp	Ala	Met	Gly	Ala	Val	Arg	Ser	Leu	Val
					325					330					335	
	Ser	Ala	Ser	Ser	Leu	Thr	Gln	Asn	Gly	Leu	Ala	Leu	Ala	Gly	Gly	Phe
				340					345					350		
	Ala	Gly	Val	Gly	Lys	Leu	Gln	Glu	Met	Ala	Thr	Lys	Asn	Ile	Thr	Asp
			355					360					365			
55	Pro	Ala	Thr	Lys	Ala	Ala	Val	Ser	Gln	Leu	Thr	Asn	Leu	Ala	Gly	Ser
		370					375					380				
	Ala	Ala	Val	Phe	Ala	Gly	Trp	Thr	Thr	Ala	Ala	Leu	Thr	Thr	Asp	Pro
		385				390					395					400
60	Ala	Val	Lys	Lys	Ala	Glu	Ser	Phe	Ile	Gln	Asp	Thr	Val	Lys	Ser	Thr
					405					410						

Lys Thr Val Lys Asp Met Gly Gly Glu Ala Ile Thr His Thr Gly Ala  
435 440 445

5 Ser Leu Arg Asn Thr Val Asn Asn Leu Arg Gln Arg Pro Ala Arg Glu  
450 455 460

Ala Asp Ile Glu Glu Gly Gly Thr Ala Ala Ser Pro Ser Glu Ile Pro  
465 470 475 480

10 Phe Arg Pro Met Arg Ser  
485

15 The DNA molecule of *ORF6* from the *Pseudomonas syringae* pv.  
tomato DC3000 CEL has a nucleotide sequence (SEQ. ID. No. 8) as follows:

atgtctggtc ctttcgagaa aaaatggcgg tgtttcacc gaaccgtgac ctacgttggc 60  
20 tggtcgctgt tctggcttct gctctgggac gtggccgtca ccgtggacgt catgctgata 120  
gaaggcaaa gcatcgactt cccctgatg cccctcacgt tgctttgctc ggcaactgac 180  
gtgctgatca gctttcgcaa ctcgagtgcc tataaccgtt ggtgggaagc gcgcaccttg 240  
tggggcgcaa tgggtcaaac ttcacgcagt tttggccggc aggtactgac gctgatcgat 300  
ggcgaacggg atgacctcaa caaccctgtc aaagccatac tctttcaacg tcatgtggct 360  
tacttgctg ccttgccgac gcacctcaaa ggccgacgtc aaacagcaaa actcgacggg 420  
25 ttactgtcgc ccgacgagat tcagcgcgcc agccagagca acaacttccc caatgacatc 480  
ctcaatggct ctgctgcggt tatctcgcaa gcctttgccg ccggccagtt cgacagcatc 540  
cgtctgaccc gcctggaatc gacctgggtc gatctgtcca actgtcaggg cgccatggag 600  
cgcatcgcca acacgccact gccctacccc tacgtttatt tcccacggct gttcagcacg 660  
ctgttctgca tctgatgccc gctgagcatg gtcaccaccc tgggctgggt caccocggcg 720  
30 atctccacgg tggtaggctg catgctgctg gcaatggacc gcatcggtac agacctgcaa 780  
gccccgttcg gcaacagtca gcaccggatc cgcattggaag acctgtgcaa caccatcgaa 840  
aagaacctgc aatcgatgtt ctcttcgcca gagaggcagc cgctgctggc tgacctgaaa 900  
agccccgtac cgtggcgctg ggccaacgca tcaattggcg gtctgagcag gcagaaaaac 960  
aggttagggg aaggcgcgag gcttatcgca agtgaaagtc tgctctgggc accatttcgc 1020  
35 tcagttgcag acgttgctcc gtgccacgcc agtgcgctacc tacgtcgccg ttga 1074

The protein or polypeptide encoded by *Pto* DC3000 CEL *ORF6* has an amino acid  
sequence (SEQ. ID. No. 9) as follows:

40 Met Ser Gly Pro Phe Glu Lys Lys Trp Arg Cys Phe Thr Arg Thr Val  
1 5 10 15

45 Thr Tyr Val Gly Trp Ser Leu Phe Trp Leu Leu Leu Trp Asp Val Ala  
20 25 30

Val Thr Val Asp Val Met Leu Ile Glu Gly Lys Gly Ile Asp Phe Pro  
35 40 45

50 Leu Met Pro Leu Thr Leu Leu Cys Ser Ala Leu Ile Val Leu Ile Ser  
50 55 60

Phe Arg Asn Ser Ser Ala Tyr Asn Arg Trp Trp Glu Ala Arg Thr Leu  
65 70 75 80

55 Trp Gly Ala Met Val Asn Thr Ser Arg Ser Phe Gly Arg Gln Val Leu  
85 90 95

60 Thr Leu Ile Asp Gly Glu Arg Asp Asp Leu Asn Asn Pro Val Lys Ala  
100 105 110

Ile Leu Phe Gln Arg His Val Ala Tyr Leu Arg Ala Leu Arg Ala His  
115 120 125

5 Leu Lys Gly Asp Val Lys Thr Ala Lys Leu Asp Gly Leu Leu Ser Pro  
130 135 140

Asp Glu Ile Gln Arg Ala Ser Gln Ser Asn Asn Phe Pro Asn Asp Ile  
145 150 155 160

10 Leu Asn Gly Ser Ala Ala Val Ile Ser Gln Ala Phe Ala Ala Gly Gln  
165 170 175

Phe Asp Ser Ile Arg Leu Thr Arg Leu Glu Ser Thr Met Val Asp Leu  
180 185 190

15 Ser Asn Cys Gln Gly Gly Met Glu Arg Ile Ala Asn Thr Pro Leu Pro  
195 200 205

20 Tyr Pro Tyr Val Tyr Phe Pro Arg Leu Phe Ser Thr Leu Phe Cys Ile  
210 215 220

Leu Met Pro Leu Ser Met Val Thr Thr Leu Gly Trp Phe Thr Pro Ala  
225 230 235 240

25 Ile Ser Thr Val Val Gly Cys Met Leu Leu Ala Met Asp Arg Ile Gly  
245 250 255

Thr Asp Leu Gln Ala Pro Phe Gly Asn Ser Gln His Arg Ile Arg Met  
260 265 270

Glu Asp Leu Cys Asn Thr Ile Glu Lys Asn Leu Gln Ser Met Phe Ser  
275 280 285

35 Ser Pro Glu Arg Gln Pro Leu Leu Ala Asp Leu Lys Ser Pro Val Pro  
290 295 300

Trp Arg Val Ala Asn Ala Ser Ile Gly Gly Leu Ser Arg Gln Lys Asn  
305 310 315 320

40 Arg Leu Gly Glu Gly Ala Arg Leu Ile Ala Ser Glu Ser Leu Leu Trp  
325 330 335

Ala Pro Phe Arg Ser Val Ala Asp Val Ala Pro Cys His Ala Ser Ala  
340 345 350

Tyr Leu Arg Arg Ala  
355

50

The DNA molecule of *ORF7* from the *Pseudomonas syringae* pv.

tomato DC3000 CEL has a nucleotide sequence (SEQ. ID. No. 10) as follows:

atgtatatcc agcaatctgg cgcccaatca ggggttgccg ctaagacgca acacgataag 60  
55 cccctgctcat tgctcggact cgccccgggt tcgctcggatg cgttcgccc ttttcatccc 120  
gaaaaggcgg gcgcctttgt ccatttgag gggcatgaag aggtctttt cgatgcgcgc 180  
tcttcccttt cgctcggctga tgccgctgat cttcccagtc ccgagcaggt acaaccccag 240  
cttcattcgt tgcgtaccct gctaccgat ctgatggtct ctatcgctc attacgtgac 300  
ggcgccacgc aatacatcaa gaccagaatc aaggctatgg cggacaacag cataggcgcg 360  
60 actgcgaaca tcgaagccaa aagaaagatt gcccaagagc acggctgtca gcttgtccac 420  
ccgtttcacc agagcaaatt tctatttgaa aaaactatcg atgatatagac gtttgctgct 480  
gactatggcc gcgcgggtgg cgacgggcac gcttgtctgg ggctatcagt aaattggtgt 540  
cagagccgtg caaaagggca gtcggatgag gccttctttc acaaactgga ggactatcag 600

5 ggcgatgcat tgctaccag ggtaatgggc ttccagcata tcgagcagca ggccatttca 660  
aacaagttgc agaacgcagc acctatgctt ctggacacac ttcccaagtt gggcatgaca 720  
cttggaaaag ggctgggcag agcacagcac gcgcactatg cggttgctct ggaaaacctt 780  
gatcgcgatc tcaaagcagt gttgcagccc ggtaaagacc agatgcttct gtttttgagt 840  
gatagccatg cgatggctct gcatcaggac agtcagggat gtctgcattt ttttgatcct 900  
ctttttggcg tggttcaggc agacagcttc agcaacatga gccattttct tgctgatgtg 960  
ttcaagcgcg acgtaggtac gcactggcgt ggcacggagc aacgtctgca actgagcgaa 1020  
atgggtgccca gaggagactt tcacttgcca taa 1053

10

The protein or polypeptide encoded by *Pto* DC3000 CEL *ORF7* has an amino acid sequence (SEQ. ID. No. 11) as follows:

15 Met Tyr Ile Gln Gln Ser Gly Ala Gln Ser Gly Val Ala Ala Lys Thr  
1 5 10 15  
Gln His Asp Lys Pro Ser Ser Leu Ser Gly Leu Ala Pro Gly Ser Ser  
20 20 25 30  
20 Asp Ala Phe Ala Arg Phe His Pro Glu Lys Ala Gly Ala Phe Val Pro  
35 40 45  
Leu Glu Gly His Glu Glu Val Phe Phe Asp Ala Arg Ser Ser Phe Ser  
25 50 55 60  
25 Ser Val Asp Ala Ala Asp Leu Pro Ser Pro Glu Gln Val Gln Pro Gln  
65 70 75 80  
30 Leu His Ser Leu Arg Thr Leu Leu Pro Asp Leu Met Val Ser Ile Ala  
85 90 95  
Ser Leu Arg Asp Gly Ala Thr Gln Tyr Ile Lys Thr Arg Ile Lys Ala  
100 105 110  
35 Met Ala Asp Asn Ser Ile Gly Ala Thr Ala Asn Ile Glu Ala Lys Arg  
115 120 125  
Lys Ile Ala Gln Glu His Gly Cys Gln Leu Val His Pro Phe His Gln  
40 130 135 140  
Ser Lys Phe Leu Phe Glu Lys Thr Ile Asp Asp Arg Ala Phe Ala Ala  
145 150 155 160  
45 Asp Tyr Gly Arg Ala Gly Gly Asp Gly His Ala Cys Leu Gly Leu Ser  
165 170 175  
Val Asn Trp Cys Gln Ser Arg Ala Lys Gly Gln Ser Asp Glu Ala Phe  
180 185 190  
50 Phe His Lys Leu Glu Asp Tyr Gln Gly Asp Ala Leu Leu Pro Arg Val  
195 200 205  
Met Gly Phe Gln His Ile Glu Gln Gln Ala Tyr Ser Asn Lys Leu Gln  
210 215 220  
55 Asn Ala Ala Pro Met Leu Leu Asp Thr Leu Pro Lys Leu Gly Met Thr  
225 230 235 240  
Leu Gly Lys Gly Leu Gly Arg Ala Gln His Ala His Tyr Ala Val Ala  
60 245 250 255  
Leu Glu Asn Leu Asp Arg Asp Leu Lys Ala Val Leu Gln Pro Gly Lys  
260 265 270

Asp Gln Met Leu Leu Phe Leu Ser Asp Ser His Ala Met Ala Leu His  
275 280 285

5 Gln Asp Ser Gln Gly Cys Leu His Phe Phe Asp Pro Leu Phe Gly Val  
290 295 300

Val Gln Ala Asp Ser Phe Ser Asn Met Ser His Phe Leu Ala Asp Val  
305 310 315 320

10 Phe Lys Arg Asp Val Gly Thr His Trp Arg Gly Thr Glu Gln Arg Leu  
325 330 335

15 Gln Leu Ser Glu Met Val Pro Arg Ala Asp Phe His Leu Arg  
340 345 350

The DNA molecule of *ORF8* from the *Pseudomonas syringae* pv. tomato DC3000 CEL has a nucleotide sequence (SEQ. ID. No. 12) as follows:

20 atgcggcctg tcgaggcaaa agatcggctt tatcagtggc tgcgcaatcg aggcacatcgat 60  
gcgaggagg gtcaacgccca caacgtaagg accgcaatg gaagcgagtg tctgctctgg 120  
ttgccagaac aggacacttc gttgttcac ttcacacaga tcgaaaggct gacgatgccg 180  
caggacaacg tcattttgat tctggcaatg gcgctgaatc tggagcctgc tcgcacaggt 240  
25 ggcgctgcgc ttggctataa ccctgattca agggaaactgt tggtgcgcag tgtgcaactca 300  
atggcggatc tggatgagac cggacttgat cacctcatga cgcaattag cacattggcc 360  
gtctcgttgc agcgctatct ggaagattat cgacgccagg agcaagccgg aaaaaccgcc 420  
cagaaagagc ctcggttctt accggctgtc catctgaccc cacgaacgtt catgacctga 480

The protein or polypeptide encoded by *Pto* DC3000 CEL *ORF8* has an amino acid sequence (SEQ. ID. No. 13) as follows:

35 Met Arg Pro Val Glu Ala Lys Asp Arg Leu Tyr Gln Trp Leu Arg Asn  
1 5 10 15

Arg Gly Ile Asp Ala Gln Glu Gly Gln Arg His Asn Val Arg Thr Ala  
20 25 30

40 Asn Gly Ser Glu Cys Leu Leu Trp Leu Pro Glu Gln Asp Thr Ser Leu  
35 40 45

Phe Ile Phe Thr Gln Ile Glu Arg Leu Thr Met Pro Gln Asp Asn Val  
50 55 60

45 Ile Leu Ile Leu Ala Met Ala Leu Asn Leu Glu Pro Ala Arg Thr Gly  
65 70 75 80

50 Gly Ala Ala Leu Gly Tyr Asn Pro Asp Ser Arg Glu Leu Leu Leu Arg  
85 90 95

Ser Val His Ser Met Ala Asp Leu Asp Glu Thr Gly Leu Asp His Leu  
100 105 110

55 Met Thr Arg Ile Ser Thr Leu Ala Val Ser Leu Gln Arg Tyr Leu Glu  
115 120 125

Asp Tyr Arg Arg Gln Glu Gln Ala Gly Lys Thr Ala Gln Lys Glu Pro  
130 135 140

60

Arg Phe Leu Pro Ala Val His Leu Thr Pro Arg Thr Phe Met Thr  
145 150 155

- 5 The DNA molecule of *ORF9* from the *Pseudomonas syringae* pv. tomato DC3000 CEL has a nucleotide sequence (SEQ. ID. No. 14) as follows:

10 atgcttaaaa aatgcctgct actggttata tcaatgtcac ttggcggctg ctggagcctg 60  
atgattcatc tggacggcga gcgttgcac tatcccggca ctgcgaagg ttgggcgtgg 120  
ggaacccata acggagggca gagttggccc atacttatag acgtgccgtt ttccctcgcg 180  
ttggacacac tgctgctgcc ctacgacctc accgcttttc tgcccgaaaa tcttggcgggt 240  
gatgaccgca aatgtcagtt cagtggagga ttgaacgtgc tcggttga 288

- 15 The protein or polypeptide encoded by *Pto* DC3000 CEL *ORF9* has an amino acid sequence (SEQ. ID. No. 15) as follows:

20 Met Leu Lys Lys Cys Leu Leu Leu Val Ile Ser Met Ser Leu Gly Gly  
1 5 10 15  
Cys Trp Ser Leu Met Ile His Leu Asp Gly Glu Arg Cys Ile Tyr Pro  
20 25 30  
25 Gly Thr Arg Gln Gly Trp Ala Trp Gly Thr His Asn Gly Gly Gln Ser  
35 40 45  
Trp Pro Ile Leu Ile Asp Val Pro Phe Ser Leu Ala Leu Asp Thr Leu  
50 55 60  
30 Leu Leu Pro Tyr Asp Leu Thr Ala Phe Leu Pro Glu Asn Leu Gly Gly  
65 70 75 80  
Asp Asp Arg Lys Cys Gln Phe Ser Gly Gly Leu Asn Val Leu Gly  
85 90 95  
35

- The DNA molecule of *ORF10* from the *Pseudomonas syringae* pv. tomato DC3000 CEL has a nucleotide sequence (SEQ. ID. No. 16) as follows:

40 atgaaacagg tagaagtcca gatcattact gaattgcctt gtcaggttct gatacctggag 60  
caagaggcag tagcagaggg cttcagggtt cttaccgct tgatcgagga gtggaggtcc 120  
ggaaagaatc gattcgagga caagggtgaa tgccatcatg tcgtacttct ggacggcgct 180  
ctggcaggta tcggaggcct ttcgcgtgat ccgcatgccc ggggtgatat gggcaggcta 240  
cgacggttat acgtcgcaag cgcatacaaga ggtcaaggcc ttggaaagac tctggtgaat 300  
45 cgacttgtgg agcatgcggc gcaggaattt ttcgccgtgc gcctgttcac tgatactccg 360  
agcggagcaa aattttactt acgttgccggc tttcaggcag ttgacgaggt gcatgccacg 420  
catataaagc ttttaaggcg ggtttga 447

- 50 The protein or polypeptide encoded by *Pto* DC3000 CEL *ORF10* has an amino acid sequence (SEQ. ID. No. 17) as follows:

55 Met Lys Gln Val Glu Val Gln Ile Ile Thr Glu Leu Pro Cys Gln Val  
1 5 10 15

Leu Ile Leu Glu Gln Glu Ala Val Ala Glu Gly Phe Arg Phe Leu Thr  
20 25 30

5 Arg Leu Ile Glu Glu Trp Arg Ser Gly Lys Asn Arg Phe Glu Ala Lys  
35 40 45

Gly Glu Cys Leu Met Val Val Leu Leu Asp Gly Ala Leu Ala Gly Ile  
50 55 60

10 Gly Gly Leu Ser Arg Asp Pro His Ala Arg Gly Asp Met Gly Arg Leu  
65 70 75 80

Arg Arg Leu Tyr Val Ala Ser Ala Ser Arg Gly Gln Gly Leu Gly Lys  
85 90 95

15 Thr Leu Val Asn Arg Leu Val Glu His Ala Ala Gln Glu Phe Phe Ala  
100 105 110

20 Val Arg Leu Phe Thr Asp Thr Pro Ser Gly Ala Lys Phe Tyr Leu Arg  
115 120 125

Cys Gly Phe Gln Ala Val Asp Glu Val His Ala Thr His Ile Lys Leu  
130 135 140

25 Leu Arg Arg Val  
145

A DNA molecule which contains the EEL of *Pseudomonas syringae*

30 pv. tomato DC3000 has a nucleotide sequence (SEQ. ID. No. 18) as follows:

ggatccagcg gcgtattgtc gtggcgatgg aacgcgttac ggattttcag cacaccggta 60  
tcgatgaaca ggtggccgtt gcgggcttg cgggtcggca tgacacaatc gaacatatca 120  
35 acgccacggc gcacaccttc gaccagatct tcgggcttgc ctacacccat caagtaacga 180  
ggtttgtctg ctggcataag gcccggcagg taatccagca ccttgatcat ctcgtgcttg 240  
ggctcgccca ccgacagacc gccaatcgcc aggccgtcaa agccgatctc atccaggcct 300  
tcgagcgaac gcttgcgag gttctcgtgc atgccacct gaacaatgcc gaacagcgcg 360  
gcagtgtttt cgccgtgcgc gaccttgagg cgcttggccc agcgcaacga cagctccatg 420  
40 gagacacgtg ctacgtcttc gtgcggccggg tacggcggtgc actcatcgaa aatcatcacg 480  
acgtccgaac ccagggtcac ctggacctgc atcgactctt ccgggccccat gaacaccttg 540  
gcaccatcga ccggagaggc gaaggtcacg ccttcctcct tgatcttgcg catggcgccc 600  
aggctgaaca cctgaaaacc gccagagtcg gtcagaatcg gccctttcca ctgcatgaaa 660  
tcgtgcaggt cgccgtggcc cttgatgacc tcggtgcccg gacgcagcca caagtggaa 720  
45 gtgttgccca gaatcatctg cgcaccggtg gcctcgatat cacgcggcaa catgcccttg 780  
accgtgcccgt aggtgcccac cggcatgaac gccgggggtct cgaccacgcc acgcggaaa 840  
gtcaggcgac cgcgacgggc cttgccgtcg gtggccaaca actcgaaaga catacgacag 900  
gtgcgactca tgcgtgatcc tctgggtccg attcctgtgg ggccgtcggc gcgggattgc 960  
gggtgatgaa catggcatca ccgtaactga agaagcggta cccgtgttcg atggccgccg 1020  
50 cgtaggccgc catggttttc ggataaccgg cgaacgccga aaccagcatc aacagcgtgg 1080  
attcaggcaa atgaaaatta gtcaccaggc catcgaccac atgaaacggc cgccccggat 1140  
agatgaagat gtcggtgtcg ccgctaaacg gcttcaactg gccatcacgc gcggcactct 1200  
ccagcgaacg cacgctgggt gtcccagacc caatcacccg cccgccccgc gcacggcacg 1260  
ccgccacggc atcgaccacg tcttggtgta cttccagcca ttcgctgtgc atgtggtgat 1320  
cttcgatctg ctgcacacgc accggctgga acgtaccgcg gccgacgtgc agagtgacaa 1380  
55 aagcagtctc gacgcccttg gcggcaattg cttccatcaa cggctgggtc aaatgcaggc 1440  
cggcagtcgg cgcgccaca gcaccggcg cctggcgcta aacggtctga taacgctcgc 1500  
ggtcggcacc ttcgtccggg cggctctatat aaggaggcaa cggcatatgg ccgacacgat 1560  
ccagcaacgg cagcacttct tcggcaaagc gcaactcgaa cagcgcgta tgccgcgcca 1620  
ccatctcggc ctgcgcgcgc ccatcgatca ggatcgacga gcccggtttt ggcgacttgc 1680  
60 tggcagcac gtgcgccagc acacgatggc tgtccagcac gcgctcgacc agaattccta 1740  
gcttgccgcg gcagccttc tgcccgaaca aacgtgcggg aatgacacgg gtattgttga 1800  
acaccatcaa gtcgcccagc cgcaaagtct cgagcaaatc ggtgaattga cgatgtgcca 1860  
gcgcgcccgt cggcccatca agggctcaaca gacgactgct gcgacgctcg gccaacgggt 1920

	gacgagcaat	caggggaatcg	gggagttcga	aggtaaagtc	agcgacgcgc	atgatcgggt	1980
	tcgttttagca	gggcccgggaa	gtttatccgg	tttgacggca	ttagtataaaa	acctgcgtaa	2040
	atccctgttg	accaacggaa	aactcatcct	tatacttcgc	cgccattgag	ccctgatggc	2100
5	ggaattggta	gacgcggcgg	attcaaaatc	cgttttcgaa	agaagtggga	gttcgattct	2160
	ccctcggggc	accaccattg	agaaaagacc	ttgaaattca	aggctctttt	tttcgtctgg	2220
	tggaaagtgg	tctgactgag	gctgcgatct	acccacacct	cccgggaattg	gccgcggagc	2280
	gccacgact	gccttcacgc	gcagagcgtc	ggtacccgga	tcacacgacc	aaggataaac	2340
	ctatgaacaa	gatcgtctac	gtaaaaagctt	acttcaaac	cattggggag	gaagtctcgg	2400
10	ttaaagtacc	tacaggcgaa	attaaaaagg	gctttttcgg	cgacaaggaa	atcatgaaaa	2460
	aagagaccca	gtggcagcaa	accgggtggg	ctgattgtca	gatagacggg	gaacggctat	2520
	cgaagacgt	cgaagacgca	gtggcgcaac	tcaatgctga	cggttatgag	attcaaacgg	2580
	tattgcctat	attgtccggg	gcttatgatt	atgcgctcaa	ataccgatac	gaaatacgtc	2640
	acaatagaac	tgaactaagc	ccaggagacc	agtcctatgt	cttcggctat	ggctacagct	2700
15	tcaccgaagg	cgtgacgctg	gtggcgaaaa	aatttcagtc	gtctgcaagc	tgaataatag	2760
	tgacctcgtg	ccacggacgc	cgctctgccc	cctgatacga	aaacgccttc	ctcaacaaga	2820
	ggcaggcgta	ctaactgtca	caagacctgc	ccgtatcagc	aagcgcaaga	cgctcgcttc	2880
	cacgaaataa	cacggtaggt	cgcggttgcta	ctttttagcg	gcagacggcg	tgccgttgta	2940
	gttgctcggg	ttgttgctgt	tatcaagatc	gcggtcattt	ccaccgaaaag	ccgcacgggt	3000
20	ttgttgctgc	ttgtcgagat	ctttgtcggt	accgcaaac	gctgcatccg	tatgggtgatc	3060
	gttgctccagg	tccttgctgt	taccccaaaa	tgccgcgctg	gtgtgggtgg	cattgtccat	3120
	atccttgctg	ttgcccgaac	atgcccgcgc	agtcacgttg	tcgttatcca	gatccttgct	3180
	gttgccgcga	cacgtggcac	cgggtgctgt	ttcggttgctc	agatcacaa	cgtttacggc	3240
	aaatgcagg	agcgaagtgc	caatgatcgt	cagcgcaagc	agaaagccgc	cgatccttgc	3300
25	cgtcagggtt	ttatacgcgc	gcacaggtt	ttcccgata	agtgaataatg	atgaagcaag	3360
	ggttactgaa	cacgttcgat	cagtgaacta	aacagtatgt	aactgcagcc	ttctgcaaga	3420
	ccgacagagg	tcgaccaaac	tgacgctgt	ttcatacca	tcaatttcta	tagcgacctg	3480
	tcacagcgct	ctcctaccga	tgctgggagt	accaaaaaac	ttccgcactg	catttttttg	3540
	cagtgtcgga	tggtttgacc	gggtttgggg	agaattgctc	aaacggagaa	cgatgagttt	3600
30	ttgttgctgc	ggcatgctaa	tcgatacatt	tatcagtgtg	tgatgcggta	tggcagcttc	3660
	atgcctccgt	caaatagtgg	acgccagtc	cgttgcataa	aacctgacgt	cactccaaaa	3720
	aaggctacgc	acgagacat	tgctgagatt	cggctgggca	ttttcgctgt	ttacacaggg	3780
	atcgagcagc	acgccccat	gcttaactca	attgtctttt	gccctgtaaa	gccctgtttt	3840
	caacaatccc	tggtttttcc	gatacatagt	ccagaaaagg	caaattccatc	acctttctgt	3900
35	tttcttttgc	tgaagatgca	tttcgcaaga	cagggccttt	atccgtcacg	ataaagaaac	3960
	cgacgtgtgt	cacatccagc	ccgggaagcg	ggggtgtaaa	tgccaatgta	atcacccgtg	4020
	cgcaggtggc	tcaccacctg	actgtcgaca	aggcggtcgc	ggatatacgt	catgctacgc	4080
	tcacaccag	gcaaccctgg	cagatagact	ttgcctttgg	ccctttcatt	aaggcgtttt	4140
	ctgacactta	ccgcaccggg	gcttatctgc	gcggtaattg	catccgccac	agggatgcc	4200
40	gttccgtaag	cccaatccgt	gaaaaagtgc	ttgcgattca	aaaagtcaac	atcgccaccc	4260
	ttgtaacgaa	cctgaacgag	attcctcaca	aaatcctgct	gcgatgttga	tcttcgaaac	4320
	gcttcgacgt	aatccagata	agcaaaaaca	tcagacctc	tgaagtcgat	gactaattgt	4380
	tcaggtacat	tcgctgagcc	caccaacatg	tttgagcggt	acgggtgttc	taaaaacgct	4440
	cctgatacaa	ggctgatcag	ctgaccttta	ttcatataac	ttttgttggg	gcggtgttcc	4500
45	agcacagcat	ccagtttttt	tgaggtgtag	gcacccagat	ttagttaa	gggtgttttc	4560
	atctctgcct	gggcacctg	aatacactt	cccggcgcgc	gccccgaaac	cccacacctt	4620
	gccaacattg	caaaggctaa	agcccatagg	gtcgtctttt	gcactctgatt	caccgtaatt	4680
	ccaaagcgct	ctcggaacctg	attgtggctc	gcgataacgc	agcaggctgc	tccattcctt	4740
	cgagatgccg	catttggttag	ctcaatcacg	gcgcactatt	taccacgtgt	catcgggtgc	4800
50	gtcatcggct	gggagcatca	gttgcaatg	cattcgcggg	ctcggcctca	gcagacgctg	4860
	gtagtgccca	gagtgcagct	gaccagcggt	ccgccatcga	ggccgcgcga	gaggccgccc	4920
	agcgatacgg	attcgtttgc	ggcaggggct	atgcccgcga	ttgaatcgcc	tgactggccc	4980
	gtgataaaagg	cctgatgcct	cagtacgcca	cctggccttac	aggcggtgtg	cattgcaata	5040
	ggctctatacc	ttttgcaagg	ttaacgaact	gtcatcaaaa	aacatggaag	cacaatcaga	5100
55	aaaaagacct	tgagtttcaa	ggctcttttt	cgtttggtga	aaagtgatct	gactcaacct	5160
	cgcatcttac	cctcctctac	tcgggttggc	cgttagcacc	caaagctacc	ttcctgcgcg	5220
	aatgctttgt	tcgttatggg	catggcggtg	tacaagcggt	aggcggtacg	cagggtccatg	5280
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65	tggaaaagca	tgagttggca	ggcgggattt	tgcaggtcat	caatggctat	ctgggtgatc	5820

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	caacgcgcaa	cccggcgtgc	ttggccgctt	ccaccaaggt	ggtgaagtta	tatttcgtgt	7020
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	acggcgccag	ctcaggtaac	ttttgcgcgt	tgaaatcatc	aaaataacgc	gctgccttgg	7380
	caatcagttt	cttgctatta	ctgtcagggt	ccataaaacc	cttgagcgtc	cccagacacg	7440
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	gctgtcgtaa	atggcctggg	ttgcgccaa	cttgcgcga	tgagcgatca	ggctggacac	8520
	tgaagcaaa	cccacgatcg	agttgagcgc	cttgccgcgc	acgcccgcct	cggcgagctg	8580
	agtcaacatg	gacggtccgc	cctcatcgct	tttgccttcc	agaagcttgc	ggcctttttt	8640
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	ggtcacgtag	gcgtggcga	tcttgtcttg	cagatcggtt	ttgttttcaa	gcacctgatt	8880
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60	tacgtccttg	tccagcttgc	tgatatcaat	cccggccacc	gcattgagcg	tcgcagaatc	9360
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	cagatttttc	gcgtcgaaac	ctttatcagg	cgtgtgcgca	gccttcttgc	gccccagcat	9480
	gcccgcttcg	tctacctgac	ccaaaaagcc	tggttgcgac	caggtgctgc	aggactgttt	9540
	gagcgctccg	gacaaccctg	ggttactttg	tgccaaaccc	ttcaggtctt	ctgcgtcgac	9600
65	attaccgtca	acttttggtc	tgctcgctgc	atccactgca	tgatgtgggt	cggcagcaat	9660
	cgccagtggc	atattggctc	gcatactgc	cgcgctgcgc	accattttcca	gtgactgcgg	9720

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25 gccncttaa aaaaanaaaa aactggntga tttatnaaaa aattttaaaa anngaaattt 11220
tttgatatac aaacttggcg naccgntttt gcccaaaact tttgggcaaa aanatnggan 11280
ctttcanggg antgatcng gaccgnaacc cttannggaa taatccgggt aaancggcta 11340
tnaaanagng ttccnctata tggnaaaatt cgggggccca ccnnttngaa ccttttggna 11400
30 accctttcaa tgttgatttg ncaaataagg gattnnccca aaagggttng ctttnggg 11458

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Several undefined nucleotides exist in SEQ. ID. No. 18, however these appear to be present in intergenic regions. The EEL of *Pseudomonas syringae* pv. tomato DC3000 contains a number of ORFs. One of the products encoded by the EEL is a homolog of TnpA' from *P. stutzeri*. An additional four products are produced by *ORF1-4*, respectively. The nucleotide sequences for a number of these ORFs and their encoded protein or polypeptide products are provided below.

The DNA molecule of *ORF1* from the *Pseudomonas syringae* pv. tomato DC3000 EEL has a nucleotide sequence (SEQ. ID. No. 19) as follows:

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40 atgagacccg tcgggtggacc ggctccaggg tattatccgc caacctatga agctgagcgt 60
cccactgcgc aagctgcagg aaacgatcgc gcccgatctt cacaggccag ttcctctcca 120
gcagccagcg ttgcgccaga gactccaatg ctgggggacc tgaagcgctt tcagccggg 180
cgctatccgg atatgaaggt agaaaatata cggtgaaaa tcgaggggca ggagcctggc 240
45 ggaaaggatg gcgtaaagca caccagaagg cgtaagccgg acgcagcagg cagcagtcac 300
gtgcacggcg tggacagctg ggcctcgacc tcggcttcag ctcaaagcaa agcattgcag 360
gatacgaact tcaaggcgag cgatcttgcc gagctcgcgc gctgggtgtga gagcccgcac 420
ccctatgcgc tggcaccctc aaaagcagcg gggaaaagca gccaaactgtc tgcaaatgtt 480
gtgagcatcc tgttgcaaga aggcaagcac gcccttgaac agcgccttga ggctcaagg 540
50 ctcaagctgg ccgacgttgt tgtctcgga ggtcgggacc accttcataaatctcaat 600
taccttgaaa tggacagttg tctggggacg tccaagggtt tatgggcacc tgacagtaat 660
gacaagaaac tgattgcaa ggcagcgctg tattttgatg atttcaacgc gcaaaagtta 720
cctgagctgg cgccgttgac gaagatgaaa agcaaggaca gtctcggtgt catgcgcgag 780
ctgttacgtg atgcgcgggg gcttgttatt ggtgagggtc acaattcaac gtccagcaag 840
55 cgtgaactga tcaataacat gaagagcttg aaggccagtg gcgtgaccac gctttttatg 900
gagcacctct gcgccagtc acatgacaag cgctcaata attacctgag cgcgccccaa 960
ggcagtcgga tgcttgccag gctgaaaaac tacctcgatt tgcagagtca gggctcatcag 1020

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5 gccccggaag agctccacac gaaatataac ttcaccacct tgggtggaagc ggccaagcac 1080  
gccggggttg gcgttggtctc gctggataca acgtccacct atatggcccc ggagaaagct 1140  
gagataaagc gtgcccaagc catgaattac tacgcagcag aaaaaataag gctgagcaaa 1200  
ccggaaggta agtgggtcgc ttttgtcggg gcaacgcacg ccacttcctg tgacggagtc 1260  
ccagggttgg cagagttgca tggggtacgc agtctggtga tcgatgatct gggcctcaag 1320  
tcccagagcga ccgtcgatat caatgtgaaa aactacggcg gcaagctgaa tccagacgtg 1380  
aggctttcct ataaggctctg a 1401

10 The protein or polypeptide encoded by *Pto* DC3000 EEL ORF1 has an amino acid sequence (SEQ. ID. No. 20) as follows:

15 Met Arg Pro Val Gly Gly Pro Ala Pro Gly Tyr Tyr Pro Pro Thr Tyr  
1 Arg 5 Gly 10 Tyr 15 Thr  
Glu Ala Glu Arg Pro Thr Ala Gln Ala Ala Gly Asn Asp Arg Ala Arg  
20 20 25 30  
Ser Ser Gln Ala Ser Ser Ser Pro Ala Ala Ser Val Ala Pro Glu Thr  
25 35 40 45  
Pro Met Leu Gly Asp Leu Lys Arg Phe Pro Ala Gly Arg Tyr Pro Asp  
50 55 60  
25 Met Lys Val Glu Asn Ile Arg Leu Lys Ile Glu Gly Gln Glu Pro Gly  
65 70 75 80  
Gly Lys Asp Gly Val Lys His Thr Arg Arg Arg Lys Pro Asp Ala Ala  
30 85 90 95  
Gly Ser Ser His Val His Gly Gly Gln Ser Val Ala Ser Thr Ser Ala  
100 105 110  
35 Ser Ala Gln Ser Lys Ala Leu Gln Asp Thr Asn Phe Lys Ala Ser Asp  
115 120 125  
Leu Ala Glu Leu Ala Arg Trp Cys Glu Ser Pro His Pro Tyr Ala Leu  
130 135 140  
40 Ala Pro Ser Lys Ala Ala Gly Lys Ser Ser Gln Leu Ser Ala Asn Val  
145 150 155 160  
Val Ser Ile Leu Leu Gln Glu Gly Lys His Ala Leu Glu Gln Arg Leu  
165 170 175  
45 Glu Ala Gln Gly Leu Lys Leu Ala Asp Val Val Val Ser Glu Gly Arg  
180 185 190  
Asp His Leu His Ile Asn Leu Asn Tyr Leu Glu Met Asp Ser Cys Leu  
50 195 200 205  
Gly Thr Ser Lys Gly Leu Trp Ala Pro Asp Ser Asn Asp Lys Lys Leu  
210 215 220  
55 Ile Ala Lys Ala Ala Arg Tyr Phe Asp Asp Phe Asn Ala Gln Lys Leu  
225 230 235 240  
Pro Glu Leu Ala Pro Leu Thr Lys Met Lys Ser Lys Asp Ser Leu Gly  
245 250 255  
60 Val Met Arg Glu Leu Leu Arg Asp Ala Pro Gly Leu Val Ile Gly Glu  
260 265 270

Gly His Asn Ser Thr Ser Ser Lys Arg Glu Leu Ile Asn Asn Met Lys  
 275 280 285  
 5 Ser Leu Lys Ala Ser Gly Val Thr Thr Leu Phe Met Glu His Leu Cys  
 290 295 300  
 Ala Glu Ser His Asp Lys Ala Leu Asn Asn Tyr Leu Ser Ala Pro Lys  
 305 310 315 320  
 10 Gly Ser Pro Met Pro Ala Arg Leu Lys Asn Tyr Leu Asp Leu Gln Ser  
 325 330 335  
 Gln Gly His Gln Ala Pro Glu Glu Leu His Thr Lys Tyr Asn Phe Thr  
 340 345 350  
 15 Thr Leu Val Glu Ala Ala Lys His Ala Gly Leu Arg Val Val Ser Leu  
 355 360 365  
 Asp Thr Thr Ser Thr Tyr Met Ala Pro Glu Lys Ala Glu Ile Lys Arg  
 370 375 380  
 Ala Gln Ala Met Asn Tyr Tyr Ala Ala Glu Lys Ile Arg Leu Ser Lys  
 385 390 395 400  
 25 Pro Glu Gly Lys Trp Val Ala Phe Val Gly Ala Thr His Ala Thr Ser  
 405 410 415  
 Cys Asp Gly Val Pro Gly Leu Ala Glu Leu His Gly Val Arg Ser Leu  
 420 425 430  
 30 Val Ile Asp Asp Leu Gly Leu Lys Ser Arg Ala Thr Val Asp Ile Asn  
 435 440 445  
 Val Lys Asn Tyr Gly Gly Lys Leu Asn Pro Asp Val Arg Leu Ser Tyr  
 450 455 460  
 Lys Val  
 465  
 40

The DNA molecule of *ORF2* from the *Pseudomonas syringae* pv.  
 tomato DC3000 EEL has a nucleotide sequence (SEQ. ID. No. 21) as follows:

45 atgcaaaaga cgaccctatg ggcttttagcc tttgcaatgt tggcagggtg tgggggtttcg 60  
 gggccggcgc cggaagtga tattcagggg gcccaggcag agatgaaaac acccgttaaa 120  
 ctaaattctgg atgcctacac ctcaaaaaaa ctggatgctg tgctggaagc ccgcaccaac 180  
 aaaagttata tgaataaagg tcagctgacg gaccttgatc caggagcgtt tttaggaaca 240  
 ccgtaccgct caaacatggt ggtgggctca gcgaatgtac ctgaacaatt agtcatcgac 300  
 50 ttcagaggtc tggattgttt tgcttatctg gattacgtcg aagcgtttcg aagatcaaca 360  
 tcgcagcagg attttgtgag gaatctcggt caggttcggt acaagggtgg cgatgttgac 420  
 tttttgaatc gcaagcactt tttcacggat tgggcttacg gaacggcata ccctgtggcg 480  
 gatgacatta ccgcgcagat aagccccggg gcggttaagt tcagaaaacg ccttaatgaa 540  
 agggccaaag gcaaagtcta tctgccaggg ttgcctgtgg ttgagcgtag catgacgtat 600  
 55 atccccgagcc gccttgtcga cagtcagggt gtgagccacc tgcgcaccgg tgattacatt 660  
 ggcatattaca ccccgcttc ccgggctgga tgtgacacac gtcggtttct ttatcgtgac 720  
 ggataa 726

The protein or polypeptide encoded by *Pto* DC3000 EEL ORF2 has an amino acid  
 60 sequence (SEQ. ID. No. 22) as follows:

Met Gln Lys Thr Thr Leu Trp Ala Leu Ala Phe Ala Met Leu Ala Gly  
1 5 10 15

5 Cys Gly Val Ser Gly Pro Ala Pro Gly Ser Asp Ile Gln Gly Ala Gln  
20 25 30

Ala Glu Met Lys Thr Pro Val Lys Leu Asn Leu Asp Ala Tyr Thr Ser  
35 40 45

10 Lys Lys Leu Asp Ala Val Leu Glu Ala Arg Thr Asn Lys Ser Tyr Met  
50 55 60

Asn Lys Gly Gln Leu Ile Asp Leu Val Ser Gly Ala Phe Leu Gly Thr  
65 70 75 80

15 Pro Tyr Arg Ser Asn Met Leu Val Gly Ser Ala Asn Val Pro Glu Gln  
85 90 95

20 Leu Val Ile Asp Phe Arg Gly Leu Asp Cys Phe Ala Tyr Leu Asp Tyr  
100 105 110

Val Glu Ala Phe Arg Arg Ser Thr Ser Gln Gln Asp Phe Val Arg Asn  
115 120 125

25 Leu Val Gln Val Arg Tyr Lys Gly Gly Asp Val Asp Phe Leu Asn Arg  
130 135 140

Lys His Phe Phe Thr Asp Trp Ala Tyr Gly Thr Ala Tyr Pro Val Ala  
145 150 155 160

30 Asp Asp Ile Thr Ala Gln Ile Ser Pro Gly Ala Val Ser Val Arg Lys  
165 170 175

35 Arg Leu Asn Glu Arg Ala Lys Gly Lys Val Tyr Leu Pro Gly Leu Pro  
180 185 190

Val Val Glu Arg Ser Met Thr Tyr Ile Pro Ser Arg Leu Val Asp Ser  
195 200 205

40 Gln Val Val Ser His Leu Arg Thr Gly Asp Tyr Ile Gly Ile Tyr Thr  
210 215 220

Pro Ala Ser Arg Ala Gly Cys Asp Thr Arg Arg Phe Leu Tyr Arg Asp  
225 230 235 240

45 Gly

The DNA molecule of *ORF3* from the *Pseudomonas syringae* pv.

tomato DC3000 EEL has a nucleotide sequence (SEQ. ID. No. 23) as follows:

50 atgcgcgcgt ataaaaacct gacggcaaag atcggcggct ttctgcttgc gctgacgac 60  
attggcactt cgctacctgc atttgccgta aacgattgtg atctggacaa cgacaacagc 120  
accggtgccg cgtgtggcgg caacgacaag gatctggata acgacaacgt gactgacgcg 180  
55 gcatttggcg gcaacgacaa ggatatggac aatgaccacc acaccgacgc ggcatttggg 240  
ggtaacgaca aggacctgga caacgatcac catacggatg cagcgtttgg cggtaacgac 300  
aaagatctcg acaacgacaa caaaaccgat gcggctttcg gtggaaatga ccgcgatctt 360  
gataacgaca acaacaccga caactacaac ggcacgccgt ctgccgctaa aaagtag 417

60 The protein or polypeptide encoded by *Pto* DC3000 EEL *ORF3* has an amino acid  
sequence (SEQ. ID. No. 24) as follows:

Met Arg Ala Tyr Lys Asn Leu Thr Ala Lys Ile Gly Gly Phe Leu Leu  
1 5 10 15

5 Ala Leu Thr Ile Ile Gly Thr Ser Leu Pro Ala Phe Ala Val Asn Asp  
20 25 30

Cys Asp Leu Asp Asn Asp Asn Ser Thr Gly Ala Thr Cys Gly Gly Asn  
35 40 45

10 Asp Lys Asp Leu Asp Asn Asp Asn Val Thr Asp Ala Ala Phe Gly Gly  
50 55 60

15 Asn Asp Lys Asp Met Asp Asn Asp His His Thr Asp Ala Ala Phe Gly  
65 70 75 80

Gly Asn Asp Lys Asp Leu Asp Asn Asp His His Thr Asp Ala Ala Phe  
85 90 95

20 Gly Gly Asn Asp Lys Asp Leu Asp Asn Asp Asn Lys Thr Asp Ala Ala  
100 105 110

Phe Gly Gly Asn Asp Arg Asp Leu Asp Asn Asp Asn Asn Thr Asp Asn  
115 120 125

25 Tyr Asn Gly Thr Pro Ser Ala Ala Lys Lys  
130 135

30 *P. s. syringae* pv. *tomato* DC3000 EEL ORF3 has now been shown to significantly reduce virulence when mutated. Perhaps more interestingly, overexpression strongly increases lesion size. Hence, this effector is biologically active and appears to have a key role in symptom production.

The DNA molecule of *ORF4* from the *Pseudomonas syringae* pv.

35 tomato DC3000 EEL has a nucleotide sequence (SEQ. ID. No. 25) as follows:

atgaacaaga tcgtctacgt aaaagcttac ttcaaaccga ttggggagga agtctcggtt 60  
aaagtaccta caggcgaaat taaaaagggc tttttcggcg acaaggaaat catgaaaaaa 120  
gagacccagt ggcagcaaac cgggtggtct gattgtcaga tagacggtga acggctatcg 180  
40 aaagacgtcg aagacgcagt ggcgcaactc aatgctgacg gttatgagat tcaaacggtg 240  
ttgcctatat tgtccggggc ttatgattat gcgctcaaat accgatacga aatacgtcac 300  
aatagaactg aactaagccc aggagaccag tcctatgtct tcggctatgg ctacagcttc 360  
accgaaggcg tgacgctggt ggcgaaaaaa tttcagtcgt ctgcaagctg a 411

45 The protein or polypeptide encoded by *Pto* DC3000 EEL *ORF4* has an amino acid sequence (SEQ. ID. No. 26) as follows:

Met Asn Lys Ile Val Tyr Val Lys Ala Tyr Phe Lys Pro Ile Gly Glu  
1 5 10 15

Glu Val Ser Val Lys Val Pro Thr Gly Glu Ile Lys Lys Gly Phe Phe  
20 25 30

55 Gly Asp Lys Lys Glu Ile Met Lys Lys Glu Thr Gln Trp Gln Gln Thr Gly  
35 40 45

Trp Ser Asp Cys Gln Ile Asp Gly Glu Arg Leu Ser Lys Asp Val Glu  
50 55 60

5 Asp Ala Val Ala Gln Leu Asn Ala Asp Gly Tyr Glu Ile Gln Thr Val  
65 70 75 80

Leu Pro Ile Leu Ser Gly Ala Tyr Asp Tyr Ala Leu Lys Tyr Arg Tyr  
85 90 95

10 Glu Ile Arg His Asn Arg Thr Glu Leu Ser Pro Gly Asp Gln Ser Tyr  
100 105 110

Val Phe Gly Tyr Gly Tyr Ser Phe Thr Glu Gly Val Thr Leu Val Ala  
115 120 125

15 Lys Lys Phe Gln Ser Ser Ala Ser  
130 135

20 The EEL of *Pseudomonas syringae* pv. *syringae* B728a contains a number of ORFs. Two of the open reading frames appear to be mobile genetic elements without comparable homologs in EELs of other *Pseudomonas syringae* variants. An additional four products are produced by *ORF1-2* and *ORF5-6*, respectively. The nucleotide sequences for a number of these ORFs and their encoded protein or polypeptide products are provided below.

The DNA molecule of *ORF1* from the *Pseudomonas syringae* pv. *syringae* B728a EEL has a nucleotide sequence (SEQ. ID. No. 27) as follows:

30 atggggttgcg tatcgtcaaa agcatctgtc atttcttcgg acagctttcg cgcatacatat 60  
acaaactctc cagaggcac ctcagtcctat caacgagcca ggacgccaag gtgcggtgag 120  
cttcaggggc cccaagttag cagattgatg ccttaccagc aggcgttagt aggtgtggcc 180  
cgatggccta atccgcattt taacagggac gatgcgcccc accagatgga gtatggagaa 240  
tcgttctacc ataaaagccg agagcttggt gcgtcggtcg ccaatggaga gatagaaaacg 300  
tttcaggagc tctggagtga agctcgtgat tggagagctt ccagagcagg ccaagatgct 360  
35 cggcttttta gtccatcgcg tgatcccaac tcttcacggg cgtttggttac gcctataact 420  
ggaccatacg aattttttaa agatagattc gcaaaccgta aagatggaga aaagcataag 480  
atgatggatt ttctcccaca cagcaatacg tttaggtttc atgggaaaat tgacggtgag 540  
cgacttcctc tcacctggat ctcgataagt tctgatcgtc gtgccgacag aacaaaggat 600  
ccttaccaaa ggttgcgcg ccaaggcatg aacgatgtgg gtgagcctaa tgtgatgttg 660  
40 cacacccaag ccgagtatgt gcccaaaatt atgcaacatg tggagcatct ttataaggcc 720  
gctacggatg ctgcattgtc cgatgccaat gcgctgaaaa aactcgcaga gatacattgg 780  
tgagcggtag aagctgttcc cgactttcgt ggaagtgcag ctaaggctga gctctgcgtg 840  
cgctccattg cccaggcaag gggcatggac ctgcccgcga tgagactcgg catcgtgccg 900  
gatctggaag cgcttacgat gcctttgaaa gactttgtga aaagttacga agggttcttc 960  
45 gaacataact ga 972

The protein or polypeptide encoded by *Psy* B728a EEL *ORF1* has an amino acid sequence (SEQ. ID. No. 28) as follows:

50 Met Gly Cys Val Ser Ser Lys Ala Ser Val Ile Ser Ser Asp Ser Phe  
1 5 10 15

55 Arg Ala Ser Tyr Thr Asn Ser Pro Glu Ala Ser Ser Val His Gln Arg  
20 25 30

Ala Arg Thr Pro Arg Cys Gly Glu Leu Gln Gly Pro Gln Val Ser Arg  
35 40 45

5 Leu Met Pro Tyr Gln Gln Ala Leu Val Gly Val Ala Arg Trp Pro Asn  
50 55 60

Pro His Phe Asn Arg Asp Asp Ala Pro His Gln Met Glu Tyr Gly Glu  
65 70 75 80

10 Ser Phe Tyr His Lys Ser Arg Glu Leu Gly Ala Ser Val Ala Asn Gly  
85 90 95

15 Glu Ile Glu Thr Phe Gln Glu Leu Trp Ser Glu Ala Arg Asp Trp Arg  
100 105 110

Ala Ser Arg Ala Gly Gln Asp Ala Arg Leu Phe Ser Ser Ser Arg Asp  
115 120 125

20 Pro Asn Ser Ser Arg Ala Phe Val Thr Pro Ile Thr Gly Pro Tyr Glu  
130 135 140

Phe Leu Lys Asp Arg Phe Ala Asn Arg Lys Asp Gly Glu Lys His Lys  
145 150 155 160

25 Met Met Asp Phe Leu Pro His Ser Asn Thr Phe Arg Phe His Gly Lys  
165 170 175

30 Ile Asp Gly Glu Arg Leu Pro Leu Thr Trp Ile Ser Ile Ser Ser Asp  
180 185 190

Arg Arg Ala Asp Arg Thr Lys Asp Pro Tyr Gln Arg Leu Arg Asp Gln  
195 200 205

35 Gly Met Asn Asp Val Gly Glu Pro Asn Val Met Leu His Thr Gln Ala  
210 215 220

Glu Tyr Val Pro Lys Ile Met Gln His Val Glu His Leu Tyr Lys Ala  
225 230 235 240

40 Ala Thr Asp Ala Ala Leu Ser Asp Ala Asn Ala Leu Lys Lys Leu Ala  
245 250 255

Glu Ile His Trp Trp Thr Val Gln Ala Val Pro Asp Phe Arg Gly Ser  
260 265 270

45 Ala Ala Lys Ala Glu Leu Cys Val Arg Ser Ile Ala Gln Ala Arg Gly  
275 280 285

50 Met Asp Leu Pro Pro Met Arg Leu Gly Ile Val Pro Asp Leu Glu Ala  
290 295 300

Leu Thr Met Pro Leu Lys Asp Phe Val Lys Ser Tyr Glu Gly Phe Phe  
305 310 315 320

55 Glu His Asn

60 As indicated in Table 1 (see Example 2), the DNA molecule encoding this protein or polypeptide bears significant homology to the nucleotide sequence from *Pseudomonas syringae* pv. *phaseolicola* which encodes AvrPphC.

The DNA molecule of *ORF2* from the *Pseudomonas syringae* pv. *syringae* B728a EEL has a nucleotide sequence (SEQ. ID. No. 29) as follows:

```

5  atgagaattc acagttccgg tcatggcatc tccggaccag tatcctctgc agaaaccggt 60
   gaaaaggccg tgcaatcatc ggccaagcg cagaatgaag cgtctcacag cgttccatca 120
   gaacatcctg aatcccgtc ctgtcaggca cgcccgaact acccttattc gtcagtcaaa 180
   acacggttac cccctgttgc gtctgcaggg cagtgcgtgt ctgagacacc ctcttcattg 240
   cctggctacc tgctgttacg tcggcttgat cgtcgtccgc tggaccagga cgcaataaag 300
   gggcttattc ctgctgatga agcagtgggc gaagcgcgcc gcgcgttgcc ctccggcagg 360
10  ggcaacattg atgtggatgc gcaacgctcc aacctggaaa gcggggcccg cacgctcgcc 420
   gcaagacgcc tgagaaaaga cgccgagacg gcgggtcatg agccgatgcc cgagaacgaa 480
   gacatgaact ggcattgtgt ggttgccatg tcgggtcagg tgttcggggc tggcaactgt 540
   ggcaacatg cccgtatagc gagctttgcc tacggtgcat cggctcagga aaaaggacgc 600
   gctggcgatg aaaatattca tctggctgcg cagagcgggg aagatcatgt ctgggctgaa 660
15  acggatgatt ccagcgtggt ctcttcgcct attgtcatgg accctggtc aaacggctct 720
   gccgtttttg cagaggacag tcggtttgct aaagataggc gcgcggtaga gcgaacggat 780
   tcgttcacgc tttcaaccgc tgccaaagca ggcaagatta cacgagagac agccgagaag 840
   gcgctgaccc aagcgaccag ccgtttgcag caacgtcttg ctgatcagca gccgcaagtc 900
   tcgccgggtg aaggtggtcg ctatcggcaa gaaaactcgg tgcttgatga tgcgttcgcc 960
20  cgacgagtca gtgacatgtt gaacaatgcc gatccacggc gtgattgca ggtggaaatc 1020
   gaggcgtccg gagttgcaat gtcgtgggt gcccaaggcg tcaagacggt cgtccgacag 1080
   gcgccaaaag tggtcaggca agccagaggc gtcgcatctg ctaaagggtat gtctccgcga 1140
   gcaacctga                                     1149

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The protein or polypeptide encoded by *Psy* B728a EEL *ORF2* has an amino acid sequence (SEQ. ID. No. 30) as follows:

```

30  Met Arg Ile His Ser Ser Gly His Gly Ile Ser Gly Pro Val Ser Ser
    1           5           10           15

    Ala Glu Thr Val Glu Lys Ala Val Gln Ser Ser Ala Gln Ala Gln Asn
           20           25           30

35  Glu Ala Ser His Ser Gly Pro Ser Glu His Pro Glu Ser Arg Ser Cys
    35           40           45

    Gln Ala Arg Pro Asn Tyr Pro Tyr Ser Ser Val Lys Thr Arg Leu Pro
    50           55           60

40  Pro Val Ala Ser Ala Gly Gln Ser Leu Ser Glu Thr Pro Ser Ser Leu
    65           70           75           80

45  Pro Gly Tyr Leu Leu Leu Arg Arg Leu Asp Arg Arg Pro Leu Asp Gln
           85           90           95

    Asp Ala Ile Lys Gly Leu Ile Pro Ala Asp Glu Ala Val Gly Glu Ala
    100          105          110

50  Arg Arg Ala Leu Pro Phe Gly Arg Gly Asn Ile Asp Val Asp Ala Gln
    115          120          125

    Arg Ser Asn Leu Glu Ser Gly Ala Arg Thr Leu Ala Ala Arg Arg Leu
    130          135          140

55  Arg Lys Asp Ala Glu Thr Ala Gly His Glu Pro Met Pro Glu Asn Glu
    145          150          155          160

60  Asp Met Asn Trp His Val Leu Val Ala Met Ser Gly Gln Val Phe Gly
    165          170          175

```

Ala Gly Asn Cys Gly Glu His Ala Arg Ile Ala Ser Phe Ala Tyr Gly  
180 185 190

5 Ala Ser Ala Gln Glu Lys Gly Arg Ala Gly Asp Glu Asn Ile His Leu  
195 200 205

Ala Ala Gln Ser Gly Glu Asp His Val Trp Ala Glu Thr Asp Asp Ser  
210 215 220

10 Ser Ala Gly Ser Ser Pro Ile Val Met Asp Pro Trp Ser Asn Gly Pro  
225 230 235 240

Ala Val Phe Ala Glu Asp Ser Arg Phe Ala Lys Asp Arg Arg Ala Val  
245 250 255

15 Glu Arg Thr Asp Ser Phe Thr Leu Ser Thr Ala Ala Lys Ala Gly Lys  
260 265 270

Ile Thr Arg Glu Thr Ala Glu Lys Ala Leu Thr Gln Ala Thr Ser Arg  
275 280 285

20 Leu Gln Gln Arg Leu Ala Asp Gln Gln Ala Gln Val Ser Pro Val Glu  
290 295 300

25 Gly Gly Arg Tyr Arg Gln Glu Asn Ser Val Leu Asp Asp Ala Phe Ala  
305 310 315 320

Arg Arg Val Ser Asp Met Leu Asn Asn Ala Asp Pro Arg Arg Ala Leu  
325 330 335

30 Gln Val Glu Ile Glu Ala Ser Gly Val Ala Met Ser Leu Gly Ala Gln  
340 345 350

35 Gly Val Lys Thr Val Val Arg Gln Ala Pro Lys Val Val Arg Gln Ala  
355 360 365

Arg Gly Val Ala Ser Ala Lys Gly Met Ser Pro Arg Ala Thr  
370 375 380

40

As indicated in Table 1 (see Example 2), the DNA molecule encoding this protein or polypeptide bears significant homology to the nucleotide sequence from *Pseudomonas syringae* pv. *phaseolicola* which encodes AvrPphE.

The DNA molecule of *ORF5* from the *Pseudomonas syringae* pv.

45 *syringae* B728a EEL has a nucleotide sequence (SEQ. ID. No. 31) as follows:

atgaatatct caggtccgaa cagacgtcag gggactcagg cagagaacac tgaaagcgct 60  
tcgtcatcat cggttaactaa cccaccgcta cagcgtggcg agggcagacg tctgcgacgt 120  
caggatgcgc tgccaacgga tatcagatac aacgcccaacc agacagcgac atcaccgcaa 180  
50 aacgcgcgcg cggcaggaag atatgaatca ggggccagct catccggcgc gaatgatact 240  
ccgcaggctg aaggttcaat gccttcgctg tccgcccttt tacaatttcg cctcgcgggc 300  
gggcggaacc attctgagct ggaaaatttt catactatga tgctgaactc accgaaagca 360  
tcacggggag atgctatacc tgagaagccc gaagcaatac ctaagcgctt actggagaag 420  
atggaaccga ttaacctggc ccagtttagct ttgcgtgata aggatctgca tgaatatgcc 480  
55 gtaatggtct gtaaccaagt gaaaaagggt gaaggtccga actccaatat tacgcaagga 540  
gatatcaagt tactgccgct gttcgccaaa gcggaaaata caagaaatcc cggcttgaat 600  
ctgcatacat tcaaaagtca taaagactgt taccaggcga taaaagagca aaacagggat 660  
attcaaaaaa acaagcaatc gctgagtatg cgggttggtt accccccatt caaaaagatg 720  
ccagaccacc atatagcctt ggatatccaa ctgagatacg gccatcgacc gtcgattgtc 780  
60 ggctttgagt ctgcccttgg gaacattata gatgctgcag aaagggaat acttttcagca 840

5 ttaggcaacg tcaaaatcaa aatggtagga aattttcttc aatactcgaa aactgactgc 900  
accatgtttg cgcttaataa cgccctgaaa gcttttaaac atcacgaaga atataccgcc 960  
cgtctgcaca atggagaaaa gcaggtgcct atcccggcga ccttcttgaa acatgctcag 1020  
tcaaaaagct tagtggagaa tcacccggaa aaagatacca ccgtcactaa agaccagggc 1080  
ggctctgcata tggaaacgct attacacaga aaccgtgcct accgggcgca acgatctgcc 1140  
ggtcagcacg ttacctctat tgaaggtttc agaatgcagg aaataaagag agcaggtgac 1200  
ttccttgccg caaacagggt ccgggccaaag ccttga 1236

10 The protein or polypeptide encoded by *Psy* B728a EEL *ORF5* has an amino acid sequence (SEQ. ID. No. 32) as follows:

15 Met Asn Ile Ser Gly Pro Asn Arg Arg Gln Gly Thr Gln Ala Glu Asn  
1 5 10 15  
20 Thr Glu Ser Ala Ser Ser Ser Ser Val Thr Asn Pro Pro Leu Gln Arg  
20 25 30  
25 Gly Glu Gly Arg Arg Leu Arg Arg Gln Asp Ala Leu Pro Thr Asp Ile  
35 40 45  
30 Arg Tyr Asn Ala Asn Gln Thr Ala Thr Ser Pro Gln Asn Ala Arg Ala  
50 55 60  
35 Ala Gly Arg Tyr Glu Ser Gly Ala Ser Ser Ser Gly Ala Asn Asp Thr  
65 70 75 80  
40 Pro Gln Ala Glu Gly Ser Met Pro Ser Ser Ser Ala Leu Leu Gln Phe  
85 90 95  
45 Arg Leu Ala Gly Gly Arg Asn His Ser Glu Leu Glu Asn Phe His Thr  
100 105 110  
50 Met Met Leu Asn Ser Pro Lys Ala Ser Arg Gly Asp Ala Ile Pro Glu  
115 120 125  
55 Lys Pro Glu Ala Ile Pro Lys Arg Leu Leu Glu Lys Met Glu Pro Ile  
130 135 140  
60 Asn Leu Ala Gln Leu Ala Leu Arg Asp Lys Asp Leu His Glu Tyr Ala  
145 150 155 160  
65 Val Met Val Cys Asn Gln Val Lys Lys Gly Glu Gly Pro Asn Ser Asn  
165 170 175  
70 Ile Thr Gln Gly Asp Ile Lys Leu Leu Pro Leu Phe Ala Lys Ala Glu  
180 185 190  
75 Asn Thr Arg Asn Pro Gly Leu Asn Leu His Thr Phe Lys Ser His Lys  
195 200 205  
80 Asp Cys Tyr Gln Ala Ile Lys Glu Gln Asn Arg Asp Ile Gln Lys Asn  
210 215 220  
85 Lys Gln Ser Leu Ser Met Arg Val Val Tyr Pro Pro Phe Lys Lys Met  
225 230 235 240  
90 Pro Asp His His Ile Ala Leu Asp Ile Gln Leu Arg Tyr Gly His Arg  
245 250 255  
95 Pro Ser Ile Val Gly Phe Glu Ser Ala Pro Gly Asn Ile Ile Asp Ala  
260 265 270

Ala Glu Arg Glu Ile Leu Ser Ala Leu Gly Asn Val Lys Ile Lys Met  
275 280 285

5 Val Gly Asn Phe Leu Gln Tyr Ser Lys Thr Asp Cys Thr Met Phe Ala  
290 295 300

Leu Asn Asn Ala Leu Lys Ala Phe Lys His His Glu Glu Tyr Thr Ala  
305 310 315 320

10 Arg Leu His Asn Gly Glu Lys Gln Val Pro Ile Pro Ala Thr Phe Leu  
325 330 335

Lys His Ala Gln Ser Lys Ser Leu Val Glu Asn His Pro Glu Lys Asp  
340 345 350

15 Thr Thr Val Thr Lys Asp Gln Gly Gly Leu His Met Glu Thr Leu Leu  
355 360 365

20 His Arg Asn Arg Ala Tyr Arg Ala Gln Arg Ser Ala Gly Gln His Val  
370 375 380

Thr Ser Ile Glu Gly Phe Arg Met Gln Glu Ile Lys Arg Ala Gly Asp  
385 390 395 400

25 Phe Leu Ala Ala Asn Arg Val Arg Ala Lys Pro  
405 410

The DNA molecule of *ORF6* from the *Pseudomonas syringae* pv.

30 *syringae* B728a EEL has a nucleotide sequence (SEQ. ID. No. 33) as follows:

atgacgctgg aacggattga acagcaaaat acgctgtttg tttatctgtg cgtgggcacg 60  
ctttctactc cagccagcag cacacttctg agcgatatc tggccgccaa cctctttcat 120  
35 tatgggtcca gcgatggggc ggccttcggg ctggacgaaa aaaataatga agtgctgctt 180  
tttcagcggg ttgatccggt acggattgat gaggatcact ttgtcagcgc ctgcgttcag 240  
atgatcgaag tggcgaaaaat atggcgggca aagttactgc atggccattc tgctccgctc 300  
gcctcctcaa ccaggctgac gaaagccggt ttaatgctaa ccatggcggg gactattcga 360  
tga 363

40

The protein or polypeptide encoded by *Psy* B728a EEL *ORF6* has an amino acid sequence (SEQ. ID. No. 34) as follows:

45 Met Thr Leu Glu Arg Ile Glu Gln Gln Asn Thr Leu Phe Val Tyr Leu  
1 5 10 15

Cys Val Gly Thr Leu Ser Thr Pro Ala Ser Ser Thr Leu Leu Ser Asp  
20 25 30

50 Ile Leu Ala Ala Asn Leu Phe His Tyr Gly Ser Ser Asp Gly Ala Ala  
35 40 45

Phe Gly Leu Asp Glu Lys Asn Asn Glu Val Leu Leu Phe Gln Arg Phe  
50 55 60

55 Asp Pro Leu Arg Ile Asp Glu Asp His Phe Val Ser Ala Cys Val Gln  
65 70 75 80

60 Met Ile Glu Val Ala Lys Ile Trp Arg Ala Lys Leu Leu His Gly His  
85 90 95

Ser Ala Pro Leu Ala Ser Ser Thr Arg Leu Thr Lys Ala Gly Leu Met  
100 105 110

5 Leu Thr Met Ala Gly Thr Ile Arg  
115 120

The EEL of *Pseudomonas syringae* pv. *syringae* 61 contains a number of ORFs. One of the open reading frames encodes the outer membrane protein

10 HopPsyA. The DNA molecule which encodes HopPsyA has a nucleotide sequence (SEQ. ID. No. 35) as follows:

gtgaacccta tccatgcacg cttctccagc gtagaagcgc tcagacattc aaacggtgat 60  
15 attcaggcaa tcaaattccga gggtcagttg gaagtcaacg gcaagcggtta cgagattcgt 120  
gcggccgctg acggetcaat cgcggtcctc agaccgcatc aacagtccaa agcagacaag 180  
ttcttcaaag gcgcagcgca tcttattggc ggacaaagcc agcgtgcccc aatagcccag 240  
gtactcaacg agaaagcggc ggcagttcca cgcctggaca gaatgttggg cagacgcttc 300  
gatctggaga agggcggaag tagcgtgtg ggcgcgcgca tcaaggctgc cgacagccga 360  
ctgacatcaa aacagacatt tgccagcttc cagcaatggg ctgaaaaagc tgaggcgctc 420  
20 gggcgatacc gaaatcggtg tctacatgat ctacaagagg gacacgccag acacaacgcc 480  
tatgaatgcg gcagagtcaa gaacattacc tggaaacgct acaggctctc gataacaaga 540  
aaaaccttat catacgcccc gcagatccat gatgatcggg aagaggaaga gcttgatctg 600  
ggccgataca tcgctgaaga cagaaatgcc agaaccggct tttttagaat ggttcctaaa 660  
gaccaacgcg cacctgagac aaactcggga cgacttacca ttggtgtaga acctaaatat 720  
25 ggagcgcagt tggccctcgc aatggcaacc ctgatggaca agcacaaatc tgtgacacaa 780  
ggtaaagtcg tcggtccggc aaaatatggc cagcaaatc actctgccat tctttacata 840  
aatggtgatc ttgcaaaagc agtaaaactg ggcgaaaaagc tgaaaaagct gagcgggtatc 900  
cctcctgaag gattcgtcga acatacacc ctaagcatgc agtcgacggg tctcgggtctt 960  
tcttatgccg agtcgggtga agggcagcct tccagccacg gacaggcgag aacacacgtt 1020  
30 atcatggatg ccttgaaagg ccagggcccc atggagaaca gactcaaat ggcgctggca 1080  
gaaagaggct atgaccgcga aaatccggcg ctcagggcgc gaaactga 1128

HopPsyA has an amino acid sequence (SEQ. ID. No. 36) as follows:

35 Val Asn Pro Ile His Ala Arg Phe Ser Ser Val Glu Ala Leu Arg His  
1 5 10 15  
40 Ser Asn Val Asp Ile Gln Ala Ile Lys Ser Glu Gly Gln Leu Glu Val  
20 25 30  
Asn Gly Lys Arg Tyr Glu Ile Arg Ala Ala Ala Asp Gly Ser Ile Ala  
35 40 45  
45 Val Leu Arg Pro Asp Gln Gln Ser Lys Ala Asp Lys Phe Phe Lys Gly  
50 55 60  
Ala Ala His Leu Ile Gly Gly Gln Ser Gln Arg Ala Gln Ile Ala Gln  
65 70 75 80  
50 Val Leu Asn Glu Lys Ala Ala Ala Val Pro Arg Leu Asp Arg Met Leu  
85 90 95  
Gly Arg Arg Phe Asp Leu Glu Lys Gly Gly Ser Ser Ala Val Gly Ala  
100 105 110  
Ala Ile Lys Ala Ala Asp Ser Arg Leu Thr Ser Lys Gln Thr Phe Ala  
115 120 125

Ser Phe Gln Gln Trp Ala Glu Lys Ala Glu Ala Leu Gly Arg Tyr Arg  
130 135 140

5 Asn Arg Tyr Leu His Asp Leu Gln Glu Gly His Ala Arg His Asn Ala  
145 150 155 160

Tyr Glu Cys Gly Arg Val Lys Asn Ile Thr Trp Lys Arg Tyr Arg Leu  
165 170 175

10 Ser Ile Thr Arg Lys Thr Leu Ser Tyr Ala Pro Gln Ile His Asp Asp  
180 185 190

Arg Glu Glu Glu Glu Leu Asp Leu Gly Arg Tyr Ile Ala Glu Asp Arg  
195 200 205

15 Asn Ala Arg Thr Gly Phe Phe Arg Met Val Pro Lys Asp Gln Arg Ala  
210 215 220

20 Pro Glu Thr Asn Ser Gly Arg Leu Thr Ile Gly Val Glu Pro Lys Tyr  
225 230 235 240

Gly Ala Gln Leu Ala Leu Ala Met Ala Thr Leu Met Asp Lys His Lys  
245 250 255

25 Ser Val Thr Gln Gly Lys Val Val Gly Pro Ala Lys Tyr Gly Gln Gln  
260 265 270

Thr Asp Ser Ala Ile Leu Tyr Ile Asn Gly Asp Leu Ala Lys Ala Val  
275 280 285

30 Lys Leu Gly Glu Lys Leu Lys Lys Leu Ser Gly Ile Pro Pro Glu Gly  
290 295 300

35 Phe Val Glu His Thr Pro Leu Ser Met Gln Ser Thr Gly Leu Gly Leu  
305 310 315 320

Ser Tyr Ala Glu Ser Val Glu Gly Gln Pro Ser Ser His Gly Gln Ala  
325 330 335

40 Arg Thr His Val Ile Met Asp Ala Leu Lys Gly Gln Gly Pro Met Glu  
340 345 350

Asn Arg Leu Lys Met Ala Leu Ala Glu Arg Gly Tyr Asp Pro Glu Asn  
355 360 365

45 Pro Ala Leu Arg Ala Arg Asn  
370 375

50 The remaining open reading frame, designated *shcA*, is a DNA molecule having a nucleotide sequence (SEQ. ID. No. 37) as follows:

55 atggagatgc ccgccttggc gtttgacgat aagggtgcgt gcaacatgat catcgacaag 60  
gcattcgtc tgacgtgtt gcgcgacgac acgcatcaac gtttggtgct gattggtctg 120  
cttgagccac acgaggatct acccttgacg cgctgttggt ctggcgctct caacccccctt 180  
gtgaatgccg gccccggcat tggctgggat gagcaaacgc gctgtacca cgcttaccaa 240  
agcatccgc gggaaaaagt cagcgtggag atgctgaagc tcgaaattgc aggattggtc 300  
gaatggatga agtgttggcg agaagcccg acgtga 336

60 The encoded protein or polypeptide, ShcA, has an amino acid sequence (SEQ. ID. No. 38) as follows:

Met Glu Met Pro Ala Leu Ala Phe Asp Asp Lys Gly Ala Cys Asn Met  
1 5 10 15  
5 Ile Ile Asp Lys Ala Phe Ala Leu Thr Leu Leu Arg Asp Asp Thr His  
20 25 30  
Gln Arg Leu Leu Leu Ile Gly Leu Leu Glu Pro His Glu Asp Leu Pro  
35 40 45  
10 Leu Gln Arg Leu Leu Ala Gly Ala Leu Asn Pro Leu Val Asn Ala Gly  
50 55 60  
Pro Gly Ile Gly Trp Asp Glu Gln Ser Gly Leu Tyr His Ala Tyr Gln  
15 65 70 75 80  
Ser Ile Pro Arg Glu Lys Val Ser Val Glu Met Leu Lys Leu Glu Ile  
85 90 95  
20 Ala Gly Leu Val Glu Trp Met Lys Cys Trp Arg Glu Ala Arg Thr  
100 105 110

In addition to the above DNA molecules and proteins or polypeptides,  
25 the present invention also relates to homologs of various DNA molecules of the  
present invention which have been isolated from other *Pseudomonas syringae*  
pathovars. For example, a number of AvrPphE, AvrPphF, and HopPsyA homologs  
have been identified from *Pseudomonas syringae* pathovars.

The DNA molecule from *Pseudomonas syringae* pv. *angulata* which  
30 encodes an AvrPphE homolog has a nucleotide sequence (SEQ. ID. No. 39) as  
follows:

atgagaattc acagtgcctg tcacagcctg cctgcgccag gccctagcgt ggaaaccact 60  
gaaaaggctg ttcaatcatc atcgccccag aaccccgctt cttacagttc acaaacagaa 120  
35 cgtcctgaag ccggttcgac tcaagtgcga ctgaactacc cttactcatc agtcaagaca 180  
cgcttgccac ccgtttcttc tacagggcag gccatttctg ccacgccatc ttcattgccc 240  
ggttacctgc tgttacgtcg gctcgaccga cgtccactgg atgaagacag tatcaaggct 300  
ctggttccgg cagacgaagc ggtgcgtgaa gcacgccgcg cgttgccctt cggcaggggc 360  
aacattgatg tggatgcaca acgtaccac ctgcaaagcg gcgctcgcg agtcgctgca 420  
40 aagcgcttga gaaaagatgc cgagcgcgct ggccatgagc cgatgcccg gaatgatgag 480  
atgaactggc atgttcttgt cgccatgtca gggcagggtg ttggcgctgg caactgtggc 540  
gaacatgctc gtatagcaag cttcgcttac ggggccctgg ctcaggaaag cgggcgtagt 600  
ccccgcgaaa agattcattt ggccgagcag cccggaaaag atcacgtctg ggctgaaaag 660  
gataattcca gcgctggctc ttcgcccac gtcattggacc cgtggtctaa cggcgagacc 720  
45 attttggcgg aggacagccg gtttgccaaa gatcgagta cggtagagcg aacatattca 780  
ttcacccttg caatggcagc tgaagccggc aaggttacgc gtgaaaccgc cgagaacgtt 840  
ctgacccaca cgacaagccg tctgcagaaa cgtcttgctg atcagttgcc gaacgtctca 900  
ccgcttgaag gaggccgcta tcagcaggaa aagtcggtgc ttgatgaggc gttcgcccga 960  
cgagtgcgag acaagttgaa tagtgacgat ccacggcgct cgttgccagat ggaaattgaa 1020  
50 gctgttggtg ttgcaatgct gctgggtgcc gaaggcgctc agacggctcg ccgacaggcg 1080  
ccaaagggtg tcaggcaagc cagaagcgtc gcgtcgtcta aaggcatgcc tccacgaaga 1140  
taa 1143

5	Met	Arg	Ile	His	Ser	Ala	Gly	His	Ser	Leu	Pro	Ala	Pro	Gly	Pro	Ser
	1				5					10				15		
10	Val	Glu	Thr	Thr	Glu	Lys	Ala	Val	Gln	Ser	Ser	Ser	Ala	Gln	Asn	Pro
				20					25					30		
15	Ala	Ser	Tyr	Ser	Ser	Gln	Thr	Glu	Arg	Pro	Glu	Ala	Gly	Ser	Thr	Gln
			35					40					45			
20	Val	Arg	Leu	Asn	Tyr	Pro	Tyr	Ser	Ser	Val	Lys	Thr	Arg	Leu	Pro	Pro
	50						55					60				
25	Val	Ser	Ser	Thr	Gly	Gln	Ala	Ile	Ser	Ala	Thr	Pro	Ser	Ser	Leu	Pro
	65				70						75				80	
30	Gly	Tyr	Leu	Leu	Leu	Arg	Arg	Leu	Asp	Arg	Arg	Pro	Leu	Asp	Glu	Asp
					85					90					95	
35	Ser	Ile	Lys	Ala	Leu	Val	Pro	Ala	Asp	Glu	Ala	Val	Arg	Glu	Ala	Arg
				100					105					110		
40	Arg	Ala	Leu	Pro	Phe	Gly	Arg	Gly	Asn	Ile	Asp	Val	Asp	Ala	Gln	Arg
			115					120					125			
45	Thr	His	Leu	Gln	Ser	Gly	Ala	Arg	Ala	Val	Ala	Ala	Lys	Arg	Leu	Arg
		130					135					140				
50	Lys	Asp	Ala	Glu	Arg	Ala	Gly	His	Glu	Pro	Met	Pro	Gly	Asn	Asp	Glu
	145					150					155					160
55	Met	Asn	Trp	His	Val	Leu	Val	Ala	Met	Ser	Gly	Gln	Val	Phe	Gly	Ala
				165						170					175	
60	Gly	Asn	Cys	Gly	Glu	His	Ala	Arg	Ile	Ala	Ser	Phe	Ala	Tyr	Gly	Ala
			180						185					190		
65	Leu	Ala	Gln	Glu	Ser	Gly	Arg	Ser	Pro	Arg	Glu	Lys	Ile	His	Leu	Ala
			195					200					205			
70	Glu	Gln	Pro	Gly	Lys	Asp	His	Val	Trp	Ala	Glu	Thr	Asp	Asn	Ser	Ser
	210						215					220				
75	Ala	Gly	Ser	Ser	Pro	Ile	Val	Met	Asp	Pro	Trp	Ser	Asn	Gly	Ala	Ala
	225					230					235					240
80	Ile	Leu	Ala	Glu	Asp	Ser	Arg	Phe	Ala	Lys	Asp	Arg	Ser	Thr	Val	Glu
					245					250					255	
85	Arg	Thr	Tyr	Ser	Phe	Thr	Leu	Ala	Met	Ala	Ala	Glu	Ala	Gly	Lys	Val
				260					265					270		
90	Thr	Arg	Glu	Thr	Ala	Glu	Asn	Val	Leu	Thr	His	Thr	Thr	Ser	Arg	Leu
			275					280					285			
95	Gln	Lys	Arg	Leu	Ala	Asp	Gln	Leu	Pro	Asn	Val	Ser	Pro	Leu	Glu	Gly
	290						295					300				
100	Gly	Arg	Tyr	Gln	Gln	Glu	Lys	Ser	Val	Leu	Asp	Glu	Ala	Phe	Ala	Arg
	305					310					315					320

Arg Val Ser Asp Lys Leu Asn Ser Asp Asp Pro Arg Arg Ala Leu Gln  
325 330 335

5 Met Glu Ile Glu Ala Val Gly Val Ala Met Ser Leu Gly Ala Glu Gly  
340 345 350

Val Lys Thr Val Ala Arg Gln Ala Pro Lys Val Val Arg Gln Ala Arg  
355 360 365

10 Ser Val Ala Ser Ser Lys Gly Met Pro Pro Arg Arg  
370 375 380

This protein or polypeptide has GC content of about 57 percent, an estimated  
15 isoelectric point of about 9.5, and an estimated molecular weight of about 41 kDa.

The DNA molecule from *Pseudomonas syringae* pv. *glycinea* which  
encodes an AvrPphE homolog has a nucleotide sequence (SEQ. ID. No. 41) as  
follows:

20 atgagaattc acagtgctgg tcacagcctg cccgcgccag gccctagcgt ggaaaccact 60  
gaaaaggctg ttcaatcatc atcggcccag aaccccgtt cttgcagttc acaaacagaa 120  
cgctcctgaag ccggttcgac tcaagtgcga ccgaactacc cttactcatc agtcaagaca 180  
cgcttgccac ccgtttcttc cacagggcag gccatttctg acacgccatc ttcattgtcc 240  
ggttacctgc tgttacgtcg gctcgaccga cgtccactgg atgaagacag tatcaaggct 300  
25 ctgggttccgg cagacgaagc gttgcgtgaa gcacgcgcgc cgttgcccctt cggcaggggc 360  
aacattgatg tggatgcaca acgtaccacac ctgcaaagcg gcgctcgcgc agtcgctgca 420  
aagcgcttga gaaaagatgc cgagcgcgct ggccatgagc cgatgcccga gaatgatgag 480  
atgaactggc atgttcttgt cgccatgtca gggcaggtgt ttggcgctgg caactgtggc 540  
gaacatgctc gtatagcaag cttcgcttac ggggccctgg ctcaggaaag cgggcgtagt 600  
30 cccgcgcaaa agattcattt ggccgagcag cccggaaaag atcacgtctg ggctgaaacg 660  
gataattcca gcgctggctc ttcgcccac gtcatggacc cgtggtctaa cggcgtagcc 720  
atthttggcg aggacagccg gtttgccaaa gatcgcatg cggtagagcg aacatattca 780  
ttcacccctg caatggcagc tgaagccggc aaggttgccg gtgaaaccgc cgagaacggt 840  
ctgacccaca cgacaagccg tctgcagaaa cgtcttgctg atcagttgcc gaacgtctca 900  
35 ccgcttgaag gaggccgcta tcagccggaa aagtcggtgc ttgatgaggc gttcgcccga 960  
cgagtgcgag acaagttgaa tagtgacgat ccacggcggt cgttgcagat ggaaattgaa 1020  
gctggttggt ttgcaatgtc gctgggtgcc gaaggcgtca agacggtcgc ccgacaggcg 1080  
ccaaaggtgg tcaggcaagc cagaagcgtc gcgtcgtcta aaggcatgcc tccacgaaga 1140  
40 taa 1143

The amino acid sequence (SEQ. ID. No. 42) for the AvrPphE homolog of  
*Pseudomonas syringae* pv. *glycinea* is as follows:

45 Met Arg Ile His Ser Ala Gly His Ser Leu Pro Ala Pro Gly Pro Ser  
1 5 10 15

Val Glu Thr Thr Glu Lys Ala Val Gln Ser Ser Ser Ala Gln Asn Pro  
20 25 30

50 Ala Ser Cys Ser Ser Gln Thr Glu Arg Pro Glu Ala Gly Ser Thr Gln  
35 40 45

Val Arg Pro Asn Tyr Pro Tyr Ser Ser Val Lys Thr Arg Leu Pro Pro  
55 60

Val Ser Ser Thr Gly Gln Ala Ile Ser Asp Thr Pro Ser Ser Leu Ser  
65 70 75 80



The DNA molecule from *Pseudomonas syringae* pv. *tabaci* which encodes an AvrPphE homolog has a nucleotide sequence (SEQ. ID. No. 43) as follows:

```

5  atgagaattc acagtgcctg tcacagcctg cctgcgccag gccctagcgt ggaaaccact 60
   gaaaaggctg ttcaatcatc atcggcccag aaccccgctt cttgcagttc acaaacagaa 120
   cgtcctgaag cgggttcgac tcaagtgcga ccgaactacc cttactcatc agtcaagaca 180
   cgcttgccac ccgtttcttc tacagggcag gccattttctg acacgccatc ttcattgccc 240
   gggttacctg tgttacgtcg gtcgaccga cgtccactgg atgaagacag tatcaaggct 300
10  ctgggttcgg cagacgaagc ggtgcgtgaa gcacgccgcg cgttgccctt cggcaggggc 360
   aacattgatg tggatgcaca acgtaccac ctgcaaagcg gcgctcgcgc agtcgctgca 420
   aagcgtttga gaaaagatgc cgagcgcgct ggccatgagc cgatgcccgg gaatgatgag 480
   atgaactggc atgttcttgt cgccatgtca gggcaggtgt ttggcgctgg caactgtggc 540
   gaacatgctc gtatagcaag cttcgcttac ggggccctgg ctcaggaaaag cgggcgtagt 600
15  ccccgcgaaa agattcattt ggccgagcag cccggaaaag atcacgtctg ggctgaaacg 660
   gataattcca gcgctggcto ttcgcccac gtcatggacc cgtggtctaa cggcgagcc 720
   attttggcgg aggacagccg gtttgccaaa gatcgagtg cggtagagcg aacatattca 780
   ttcacccttg caatggcagc tgaagccggc aaggttacgc gtgaaactgc cgagaacgtt 840
   ctgacccaca cgacaagccg tctgcagaaa cgtcttgctg atcagttgcc gaacgtctca 900
20  ccgcttgaa gaggccgcta tcagcaggaa aagtcggtgc ttgatgaggc gttcgccccg 960
   cgagtgcgag acaagttgaa tagtgacgat ccacggcgtg cgttgagat ggaaattgaa 1020
   gctgttggtg ttgcaatgtc gctgggtgcc gaaggcgtca agacggtcgc ccgacaggcg 1080
   ccaaaggctg tcaggcaagc cagaagcgtc gcgtcgtcta aaggcatgcc tccacgaaga 1140
   taa 1143
25

```

The amino acid sequence (SEQ. ID. No. 44) for the AvrPphE homolog of *Pseudomonas syringae* pv. *tabaci* is as follows:

```

30  Met Arg Ile His Ser Ala Gly His Ser Leu Pro Ala Pro Gly Pro Ser
     1           5           10          15
   Val Glu Thr Thr Glu Lys Ala Val Gln Ser Ser Ser Ala Gln Asn Pro
           20          25          30
35  Ala Ser Cys Ser Ser Gln Thr Glu Arg Pro Glu Ala Gly Ser Thr Gln
     35          40          45
   Val Arg Pro Asn Tyr Pro Tyr Ser Ser Val Lys Thr Arg Leu Pro Pro
     50          55          60
40  Val Ser Ser Thr Gly Gln Ala Ile Ser Asp Thr Pro Ser Ser Leu Pro
     65          70          75          80
45  Gly Tyr Leu Leu Leu Arg Arg Leu Asp Arg Arg Pro Leu Asp Glu Asp
     85          90          95
   Ser Ile Lys Ala Leu Val Pro Ala Asp Glu Ala Val Arg Glu Ala Arg
           100          105          110
50  Arg Ala Leu Pro Phe Gly Arg Gly Asn Ile Asp Val Asp Ala Gln Arg
     115          120          125
   Thr His Leu Gln Ser Gly Ala Arg Ala Val Ala Ala Lys Arg Leu Arg
     130          135          140
55  Lys Asp Ala Glu Arg Ala Gly His Glu Pro Met Pro Gly Asn Asp Glu
     145          150          155          160

```

Met Asn Trp His Val Leu Val Ala Met Ser Gly Gln Val Phe Gly Ala  
165 170 175

5 Gly Asn Cys Gly Glu His Ala Arg Ile Ala Ser Phe Ala Tyr Gly Ala  
180 185 190

Leu Ala Gln Glu Ser Gly Arg Ser Pro Arg Glu Lys Ile His Leu Ala  
195 200 205

10 Glu Gln Pro Gly Lys Asp His Val Trp Ala Glu Thr Asp Asn Ser Ser  
210 215 220

Ala Gly Ser Ser Pro Ile Val Met Asp Pro Trp Ser Asn Gly Ala Ala  
225 230 235 240

15 Ile Leu Ala Glu Asp Ser Arg Phe Ala Lys Asp Arg Ser Ala Val Glu  
245 250 255

20 Arg Thr Tyr Ser Phe Thr Leu Ala Met Ala Ala Glu Ala Gly Lys Val  
260 265 270

Thr Arg Glu Thr Ala Glu Asn Val Leu Thr His Thr Thr Ser Arg Leu  
275 280 285

25 Gln Lys Arg Leu Ala Asp Gln Leu Pro Asn Val Ser Pro Leu Glu Gly  
290 295 300

Gly Arg Tyr Gln Gln Glu Lys Ser Val Leu Asp Glu Ala Phe Ala Arg  
305 310 315 320

30 Arg Val Ser Asp Lys Leu Asn Ser Asp Asp Pro Arg Arg Ala Leu Gln  
325 330 335

35 Met Glu Ile Glu Ala Val Gly Val Ala Met Ser Leu Gly Ala Glu Gly  
340 345 350

Val Lys Thr Val Ala Arg Gln Ala Pro Lys Val Val Arg Gln Ala Arg  
355 360 365

40 Ser Val Ala Ser Ser Lys Gly Met Pro Pro Arg Arg  
370 375 380

This protein or polypeptide has GC content of about 57 percent, an estimated  
45 isoelectric point of about 9.3, and an estimated molecular weight of about 41 kDa.

Another DNA molecule from *Pseudomonas syringae* pv. *tabaci* which  
encodes a AvrPphE homolog has a nucleotide sequence (SEQ. ID. No. 45) as follows:

atgagaattc acagtgtctg tcacagcctg cctgcgccag gccctagcgt ggaaaccact 60  
50 gaaaaggctg ttcaatcatc atcggccccag aaccccgtt cttgcagttc acaaacagaa 120  
cgtoctgaag ccggttcgac tcaagtgcga ccgaactacc cttactcatc agtcaagaca 180  
cgcttgccac ccgtttcttc tacagggcag gccatttctg acacgccatc ttcatgtccc 240  
ggttacctgc tgttacgtcg gctcgaccga cgtccactgg atgaagacag tatcaaggct 300  
ctgggttcgg cagacgaagc ggtgcgtgaa gcacgccgcg cgttgccctt cggcaggggc 360  
55 aacattgatg tggatgcaca acgtaccac ctgcaaagcg gcgctcgcgc agtcgctgca 420  
aagcgcttga gaaaagatgc cgagcgcgct ggccatgagc cgatgcccg gaatgatgag 480  
atgaactggc atgttcttgt cgccatgtca gggcaggtgt ttggcgctgg caactgtggc 540  
gaacatgctc gtatagcaag cttcgcttac ggggccctgg ctacaggaaag cgggcgtagt 600  
ccccgcgaaa agattcattt ggccgagcag cccggaaaag atcacgtctg ggctgaaacg 660  
60 gataattcca gcgctggctc ttgcgccatc gtcattggacc cgtggtctaa cggcgcagcc 720  
attttggcgg aggacagccg gtttgccaaa gatcgagtg cggtagagcg aacatattca 780

5 ttcacccttg caatggcagc tgaagccggc aaggttacgc gtgaaactgc cgagaacggt 840  
 ctgacccaca cgacaagccg tctgcagaaa cgtcttgctg atcagttgcc gaacgtctca 900  
 ccgcttgaag gaggccgcta tcagcaggaa aagtcggtgc ttgatgaggc gttcgcccga 960  
 cgagtgcgagc acaagttgaa tagtgacgat ccacggcgtg cgttgacgat ggaaattgaa 1020  
 gctgttggtg ttgcaatgct gctgggtgcc gaaggcgtca agacgggtcg cgcacaggcg 1080  
 ccaaagggtg tcaggcaagc cagaagcgtc gcgtcgtcta aaggcatgcc tccacgaaga 1140  
 taa 1143

10 The encoded AvrPphE homolog has an amino acid sequence according to SEQ. ID.  
 No. 46 as follows:

15 Met Arg Ile His Ser Ala Gly His Ser Leu Pro Ala Pro Gly Pro Ser  
 1 5 10 15  
 Val Glu Thr Thr Glu Lys Ala Val Gln Ser Ser Ser Ala Gln Asn Pro  
 20 20 25 30  
 Ala Ser Cys Ser Ser Gln Thr Glu Arg Pro Glu Ala Gly Ser Thr Gln  
 20 35 40 45  
 Val Arg Pro Asn Tyr Pro Tyr Ser Ser Val Lys Thr Arg Leu Pro Pro  
 50 55 60  
 25 Val Ser Ser Thr Gly Gln Ala Ile Ser Asp Thr Pro Ser Ser Leu Pro  
 65 70 75 80  
 Gly Tyr Leu Leu Leu Arg Arg Leu Asp Arg Arg Pro Leu Asp Glu Asp  
 85 90 95  
 30 Ser Ile Lys Ala Leu Val Pro Ala Asp Glu Ala Val Arg Glu Ala Arg  
 100 105 110  
 Arg Ala Leu Pro Phe Gly Arg Gly Asn Ile Asp Val Asp Ala Gln Arg  
 115 120 125  
 Thr His Leu Gln Ser Gly Ala Arg Ala Val Ala Ala Lys Arg Leu Arg  
 130 135 140  
 40 Lys Asp Ala Glu Arg Ala Gly His Glu Pro Met Pro Gly Asn Asp Glu  
 145 150 155 160  
 Met Asn Trp His Val Leu Val Ala Met Ser Gly Gln Val Phe Gly Ala  
 165 170 175  
 45 Gly Asn Cys Gly Glu His Ala Arg Ile Ala Ser Phe Ala Tyr Gly Ala  
 180 185 190  
 Leu Ala Gln Glu Ser Gly Arg Ser Pro Arg Glu Lys Ile His Leu Ala  
 195 200 205  
 50 Glu Gln Pro Gly Lys Asp His Val Trp Ala Glu Thr Asp Asn Ser Ser  
 210 215 220  
 55 Ala Gly Ser Ser Pro Ile Val Met Asp Pro Trp Ser Asn Gly Ala Ala  
 225 230 235 240  
 Ile Leu Ala Glu Asp Ser Arg Phe Ala Lys Asp Arg Ser Ala Val Glu  
 245 250 255  
 60 Arg Thr Tyr Ser Phe Thr Leu Ala Met Ala Ala Glu Ala Gly Lys Val  
 260 265 270

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Thr Arg Glu Thr Ala Glu Asn Val Leu Thr His Thr Thr Ser Arg Leu  
275 280 285

5 Gln Lys Arg Leu Ala Asp Gln Leu Pro Asn Val Ser Pro Leu Glu Gly  
290 295 300

Gly Arg Tyr Gln Gln Glu Lys Ser Val Leu Asp Glu Ala Phe Ala Arg  
305 310 315 320

10 Arg Val Ser Asp Lys Leu Asn Ser Asp Asp Pro Arg Arg Ala Leu Gln  
325 330 335

Met Glu Ile Glu Ala Val Gly Val Ala Met Ser Leu Gly Ala Glu Gly  
340 345 350

15 Val Lys Thr Val Ala Arg Gln Ala Pro Lys Val Val Arg Gln Ala Arg  
355 360 365

20 Ser Val Ala Ser Ser Lys Gly Met Pro Pro Arg Arg  
370 375 380

A DNA molecule from *Pseudomonas syringae* pv. *glycinea* race 4  
which encodes an AvrPphE homolog has a nucleotide sequence (SEQ. ID. No. 47)  
as follows:

atgagaattc acagtgtctg tccagcctg cccgcgccag gccctagcgt ggaaaccact 60  
gaaaaggctg ttcaatcatc atcggcccag aaccccgctt cttgcagttc acaaacagaa 120  
cgctctgaag ccggttcgac tcaagtgcga ccgaactacc cttactcatc agtcaagaca 180  
30 cgcttgccac ccgtttcttc cacagggcag gccatttctg acacgccatc ttcattgtcc 240  
ggttacctgc tgttacgtcg gctcgaccga cgtccactgg atgaagacag tatcaaggct 300  
ctgggttcgg cagacgaagc gttgcgtgaa gcacgcccg cgttgccctt cggcaggggc 360  
aacattgatg tggatgcaca acgtaccac ctgcaaagcg gcgctcgcgc agtcgctgca 420  
aagcgcttga gaaaagatgc cgagcgcgct ggccatgagc cgatgcccg gaatgatgag 480  
35 atgaactggc atgttcttgt cgccatgtca gggcaggtgt ttggcgttgg caactgtggc 540  
gaacatgctc gtatagcaag cttcgcttac ggggccctgg ctccaggaaag cgggcgtagt 600  
ccccgcgaaa agattcattt ggccgagcag cccggaaaag atcacgtctg ggctgaaacg 660  
gataattcca gcgctggctc ttcgccatc gtcattggacc cgtggtctaa cggcgtagcc 720  
atgttggcgg aggacagcgg gtttgccaaa gatcgagtg cggtagagcg aacatattca 780  
40 ttcacccttg caatggcagc tgaagccggc aaggttgcgc gtgaaaccgc cgagaacgtt 840  
ctgaccacaca cgacaagcgg tctgcagaaa cgtcttgctg atcagttgcc gaacgttca 900  
ccgcttgaag gaggccgcta tcagccggaa aagtcggtgc ttgatgaggc gttcgcccga 960  
cgagtgcgag acaagttgaa tagtgacgat ccacggcgtg cgttgagat ggaaattgaa 1020  
gctgttggtg ttgcaatgtc gctgggtgcc gaaggcgtca agacgggtgc ccgacaggcg 1080  
45 ccaaagggtg tcaggcaagc cagaagcgtc gcgtcgtcta aaggcatgcc tccacgaaga 1140  
taa 1143

The encoded AvrPphE homolog has an amino acid sequence according to SEQ. ID.  
No. 48 as follows:

Met Arg Ile His Ser Ala Gly His Ser Leu Pro Ala Pro Gly Pro Ser  
1 5 10 15

55 Val Glu Thr Thr Glu Lys Ala Val Gln Ser Ser Ser Ala Gln Asn Pro  
20 25 30

Ala Ser Cys Ser Ser Gln Thr Glu Arg Pro Glu Ala Gly Ser Thr Gln  
35 40 45

60

	Val	Arg	Pro	Asn	Tyr	Pro	Tyr	Ser	Ser	Val	Lys	Thr	Arg	Leu	Pro	Pro
	50						55					60				
5	Val	Ser	Ser	Thr	Gly	Gln	Ala	Ile	Ser	Asp	Thr	Pro	Ser	Ser	Leu	Ser
	65					70					75				80	
	Gly	Tyr	Leu	Leu	Leu	Arg	Arg	Leu	Asp	Arg	Arg	Pro	Leu	Asp	Glu	Asp
					85					90					95	
10	Ser	Ile	Lys	Ala	Leu	Val	Pro	Ala	Asp	Glu	Ala	Leu	Arg	Glu	Ala	Arg
				100					105					110		
	Arg	Ala	Leu	Pro	Phe	Gly	Arg	Gly	Asn	Ile	Asp	Val	Asp	Ala	Gln	Arg
			115					120					125			
15	Thr	His	Leu	Gln	Ser	Gly	Ala	Arg	Ala	Val	Ala	Ala	Lys	Arg	Leu	Arg
	130						135					140				
	Lys	Asp	Ala	Glu	Arg	Ala	Gly	His	Glu	Pro	Met	Pro	Glu	Asn	Asp	Glu
20	145					150					155					160
	Met	Asn	Trp	His	Val	Leu	Val	Ala	Met	Ser	Gly	Gln	Val	Phe	Gly	Ala
				165						170					175	
25	Gly	Asn	Cys	Gly	Glu	His	Ala	Arg	Ile	Ala	Ser	Phe	Ala	Tyr	Gly	Ala
				180					185					190		
	Leu	Ala	Gln	Glu	Ser	Gly	Arg	Ser	Pro	Arg	Glu	Lys	Ile	His	Leu	Ala
			195					200					205			
30	Glu	Gln	Pro	Gly	Lys	Asp	His	Val	Trp	Ala	Glu	Thr	Asp	Asn	Ser	Ser
	210						215					220				
	Ala	Gly	Ser	Ser	Pro	Ile	Val	Met	Asp	Pro	Trp	Ser	Asn	Gly	Val	Ala
35	225					230				235						240
	Ile	Leu	Ala	Glu	Asp	Ser	Arg	Phe	Ala	Lys	Asp	Arg	Ser	Ala	Val	Glu
				245						250					255	
40	Arg	Thr	Tyr	Ser	Phe	Thr	Leu	Ala	Met	Ala	Ala	Glu	Ala	Gly	Lys	Val
				260					265					270		
	Ala	Arg	Glu	Thr	Ala	Glu	Asn	Val	Leu	Thr	His	Thr	Thr	Ser	Arg	Leu
			275					280					285			
45	Gln	Lys	Arg	Leu	Ala	Asp	Gln	Leu	Pro	Asn	Val	Ser	Pro	Leu	Glu	Gly
	290						295					300				
	Gly	Arg	Tyr	Gln	Pro	Glu	Lys	Ser	Val	Leu	Asp	Glu	Ala	Phe	Ala	Arg
50	305					310					315					320
	Arg	Val	Ser	Asp	Lys	Leu	Asn	Ser	Asp	Asp	Pro	Arg	Arg	Ala	Leu	Gln
				325						330					335	
55	Met	Glu	Ile	Glu	Ala	Val	Gly	Val	Ala	Met	Ser	Leu	Gly	Ala	Glu	Gly
				340					345					350		
	Val	Lys	Thr	Val	Ala	Arg	Gln	Ala	Pro	Lys	Val	Val	Arg	Gln	Ala	Arg
			355					360					365			
60	Ser	Val	Ala	Ser	Ser	Lys	Gly	Met	Pro	Pro	Arg	Arg				
	370						375					380				

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A DNA molecule from *Pseudomonas syringae* pv. *phaseolicola*  
strain B130 which encodes AvrPphE has a nucleotide sequence (SEQ. ID. No. 49)  
as follows:

```
5  atgagaattc acagtgtctg tcacagcctg cccgcgccag gccctagcgt ggaaaccact 60
   gaaaaggctg ttcaatcatc atcggccccag aaccccgcctt cttgcagttc acaaacagaa 120
   cgtcctgaag ccggttcgac tcaagtgcga ccgaactacc cttactcatc agtcaagaca 180
   cgcttgccac ccgtttcttc cacagggcag gccattttctg acacgccatc ttcattgccc 240
   ggttacctgc tgttacgtcg gctcgaccga cgtccactgg atgaagacag tatcaaggct 300
10  ctgggttcgg cagacgaagc gttgcgtgaa gcacgccgcg cgttgccctt cggcaggggc 360
   aacattgatg tggatgcaca acgtaccacac ctgcaaagcg gcgctcgcgc agtcgctgca 420
   aagcgcttga gaaaagatgc cgagcgcgct ggccatgagc cgatgcccca gaatgatgag 480
   atgaactggc atgttcttgt cgccatgtca gggcaggtgt ttggcgctgg caactgtggc 540
   gaacatgctc gtatagcaag cttcgcttac ggggccctgg ctcaggaaaag cgggcgtagt 600
15  cccgcgaaa agattcattt ggccgagcag cccggaaaag atcacgtctg ggctgaaacg 660
   gataattcca gcgctggctc ttcgcccac gtcattggacc cgtggtctaa cggcgcagcc 720
   attttggcgg aggacagccg gtttgccaaa gatcgcagtg cgttagagcg aacatattca 780
   ttcacccttg caatggcagc tgaagccggc aagggttcgc gtgaaaccgc cgagaacgtt 840
   ctgacccaca cgacaagccg tctgcagaag cgtcttgctg atcagttgcc gaacgtctca 900
20  ccgcttgaag gaggccgcta tcagccggaa aagtcggtgc ttgatgaggc gttcgcccga 960
   cgagtgcgag acaagttgaa tagtgacgat ccacggcgtg cgttcgagat ggaaattgaa 1020
   gctggttggt ttgcaatgtc gctgggtgcc gaaggcgtca agacggtcgc ccgacaggcg 1080
   ccaaagggtg tcaggcaagc cagaagcgtc gcgtcgtcta aaggcatgcc tccacgaaga 1140
   taa 1143
```

The encoded AvrPphE homolog has an amino acid sequence according to SEQ. ID.  
No. 50 as follows:

```
30  Met Arg Ile His Ser Ala Gly His Ser Leu Pro Ala Pro Gly Pro Ser
     1           5           10          15

   Val Glu Thr Thr Glu Lys Ala Val Gln Ser Ser Ser Ala Gln Asn Pro
           20          25          30

35  Ala Ser Cys Ser Ser Gln Thr Glu Arg Pro Glu Ala Gly Ser Thr Gln
     35           40           45

   Val Arg Pro Asn Tyr Pro Tyr Ser Ser Val Lys Thr Arg Leu Pro Pro
     50           55           60

   Val Ser Ser Thr Gly Gln Ala Ile Ser Asp Thr Pro Ser Ser Leu Pro
     65           70           75           80

45  Gly Tyr Leu Leu Leu Arg Arg Leu Asp Arg Arg Pro Leu Asp Glu Asp
     85           90           95

   Ser Ile Lys Ala Leu Val Pro Ala Asp Glu Ala Leu Arg Glu Ala Arg
           100          105          110

50  Arg Ala Leu Pro Phe Gly Arg Gly Asn Ile Asp Val Asp Ala Gln Arg
     115          120          125

   Thr His Leu Gln Ser Gly Ala Arg Ala Val Ala Ala Lys Arg Leu Arg
     130          135          140

   Lys Asp Ala Glu Arg Ala Gly His Glu Pro Met Pro Glu Asn Asp Glu
     145          150          155          160
```

Met Asn Trp His Val Leu Val Ala Met Ser Gly Gln Val Phe Gly Ala  
165 170 175

5 Gly Asn Cys Gly Glu His Ala Arg Ile Ala Ser Phe Ala Tyr Gly Ala  
180 185 190

Leu Ala Gln Glu Ser Gly Arg Ser Pro Arg Glu Lys Ile His Leu Ala  
195 200 205

10 Glu Gln Pro Gly Lys Asp His Val Trp Ala Glu Thr Asp Asn Ser Ser  
210 215 220

Ala Gly Ser Ser Pro Ile Val Met Asp Pro Trp Ser Asn Gly Ala Ala  
225 230 235 240

15 Ile Leu Ala Glu Asp Ser Arg Phe Ala Lys Asp Arg Ser Ala Val Glu  
245 250 255

20 Arg Thr Tyr Ser Phe Thr Leu Ala Met Ala Ala Glu Ala Gly Lys Val  
260 265 270

Ala Arg Glu Thr Ala Glu Asn Val Leu Thr His Thr Thr Ser Arg Leu  
275 280 285

25 Gln Lys Arg Leu Ala Asp Gln Leu Pro Asn Val Ser Pro Leu Glu Gly  
290 295 300

Gly Arg Tyr Gln Pro Glu Lys Ser Val Leu Asp Glu Ala Phe Ala Arg  
305 310 315 320

30 Arg Val Ser Asp Lys Leu Asn Ser Asp Asp Pro Arg Arg Ala Leu Gln  
325 330 335

35 Met Glu Ile Glu Ala Val Gly Val Ala Met Ser Leu Gly Ala Glu Gly  
340 345 350

Val Lys Thr Val Ala Arg Gln Ala Pro Lys Val Val Arg Gln Ala Arg  
355 360 365

40 Ser Val Ala Ser Ser Lys Gly Met Pro Pro Arg Arg  
370 375 380

A DNA molecule from *Pseudomonas syringae* pv. *angulata* strain

45 Pa9 which encodes an AvrPphE homolog has a nucleotide sequence (SEQ. ID.  
No. 51) as follows:

atgagaattc acagtgtctg tcaacagcctg cctgcgccag gccctagcgt ggaaaccact 60  
gaaaaggctg ttcaatcatc atcggccccag aaccccgcctt cttacagttc acaaacagaa 120  
50 cgtcctgaag ccggttcgac tcaagtgcga ctgaactacc cttactcatc agtcaagaca 180  
cgcttgccac ccgtttcttc tacagggcag gccatttctg ccacgccatc ttcattgccc 240  
ggttacctgc tgttacgtcg gctcgaccga cgtccactgg atgaagacag tatcaaggct 300  
ctggttcccg cagacgaagc ggtgcgtgaa gcacgcgcgc cgttgccctt cggcaggggc 360  
aacattgatg tggatgcaca acgtacccac ctgcaaagcg gcgctcgcgc agtcgctgca 420  
55 aagcgcttga gaaaagatgc cgagcgcgct ggccatgagc cgatgcccg ggatgatgag 480  
atgaactggc atgttcttgt cgccatgtca gggcagggtgt ttggcgctgg caactgtggc 540  
gaacatgctc gtatagcaag cttcgcttac ggggcccttg ctcaggaaaag cgggcgtagt 600  
ccccgcgaaa agattcattt ggccgagcag cccggaaaag atcacgtctg ggctgaaacg 660  
gataattcca gcgctggctc ttcgcccac gtcatggacc cgtggtctaa cggcgcagcc 720  
60 attttggcgg aggacagccg gtttgccaaa gatcgagta cggtagagcg aacatattca 780  
ttcacccttg caatggcagc tgaagccggc aaggttacgc gtgaaaccgc cgagaacggt 840  
ctgaccacaca cgacaagccg tctgcagaaa cgtcttgctg atcagttgcc gaacgtctca 900

5 cgcgttgaag gaggccgcta tcagcaggaa aagtcggtgc ttgatgaggc gttcgcccga 960  
cgagtgcgcg acaagttgaa tagtgacgat ccacggcgtg cgttgcagat ggaaattgaa 1020  
gctgttggtg ttgcaatgtc gctgggtgcc gaaggcgtca agacggtcgc ccgacaggcg 1080  
ccaaaggtgg tcaggcaagc cagaagcgtc gcgtcgtcta aaggcatgcc tccacgaaga 1140  
taa 1143

The encoded AvrPphE homolog has an amino acid sequence according to SEQ. ID.

No. 52 as follows:

10 Met Arg Ile His Ser Ala Gly His Ser Leu Pro Ala Pro Gly Pro Ser  
1 5 10 15

15 Val Glu Thr Thr Glu Lys Ala Val Gln Ser Ser Ser Ala Gln Asn Pro  
20 25 30

Ala Ser Tyr Ser Ser Gln Thr Glu Arg Pro Glu Ala Gly Ser Thr Gln  
35 40 45

20 Val Arg Leu Asn Tyr Pro Tyr Ser Ser Val Lys Thr Arg Leu Pro Pro  
50 55 60

Val Ser Ser Thr Gly Gln Ala Ile Ser Ala Thr Pro Ser Ser Leu Pro  
65 70 75 80

25 Gly Tyr Leu Leu Leu Arg Arg Leu Asp Arg Arg Pro Leu Asp Glu Asp  
85 90 95

30 Ser Ile Lys Ala Leu Val Pro Ala Asp Glu Ala Val Arg Glu Ala Arg  
100 105 110

Arg Ala Leu Pro Phe Gly Arg Gly Asn Ile Asp Val Asp Ala Gln Arg  
115 120 125

35 Thr His Leu Gln Ser Gly Ala Arg Ala Val Ala Ala Lys Arg Leu Arg  
130 135 140

Lys Asp Ala Glu Arg Ala Gly His Glu Pro Met Pro Gly Asn Asp Glu  
145 150 155 160

40 Met Asn Trp His Val Leu Val Ala Met Ser Gly Gln Val Phe Gly Ala  
165 170 175

45 Gly Asn Cys Gly Glu His Ala Arg Ile Ala Ser Phe Ala Tyr Gly Ala  
180 185 190

Leu Ala Gln Glu Ser Gly Arg Ser Pro Arg Glu Lys Ile His Leu Ala  
195 200 205

50 Glu Gln Pro Gly Lys Asp His Val Trp Ala Glu Thr Asp Asn Ser Ser  
210 215 220

Ala Gly Ser Ser Pro Ile Val Met Asp Pro Trp Ser Asn Gly Ala Ala  
225 230 235 240

55 Ile Leu Ala Glu Asp Ser Arg Phe Ala Lys Asp Arg Ser Thr Val Glu  
245 250 255

60 Arg Thr Tyr Ser Phe Thr Leu Ala Met Ala Ala Glu Ala Gly Lys Val  
260 265 270

Thr Arg Glu Thr Ala Glu Asn Val Leu Thr His Thr Thr Ser Arg Leu  
275 280 285

Gln Lys Arg Leu Ala Asp Gln Leu Pro Asn Val Ser Pro Leu Glu Gly  
290 295 300

5 Gly Arg Tyr Gln Gln Glu Lys Ser Val Leu Asp Glu Ala Phe Ala Arg  
305 310 315 320

Arg Val Ser Asp Lys Leu Asn Ser Asp Asp Pro Arg Arg Ala Leu Gln  
325 330 335

10 Met Glu Ile Glu Ala Val Gly Val Ala Met Ser Leu Gly Ala Glu Gly  
340 345 350

15 Val Lys Thr Val Ala Arg Gln Ala Pro Lys Val Val Arg Gln Ala Arg  
355 360 365

Ser Val Ala Ser Ser Lys Gly Met Pro Pro Arg Arg  
370 375 380

20

A DNA molecule from *Pseudomonas syringae* pv. *delphinii* strain  
PDDCC529 which encodes a AvrPphE homolog has a nucleotide sequence (SEQ.  
ID. No. 53) as follows:

25 atgaaaatac ataacgctgg cccaagcatt ccgatgcccg ctccatcgat tgagagcgct 60  
ggcaagactg cgcaatcatc attgggtcaa ccgcagagcc aacgagccac ccccgctctcg 120  
ccatcagaga cttctgatgc ccgtccgtcc agtgtgcgta cgaactaccc ttattcatca 180  
gtcaaaacac gggttgccctcc cgttgccgtct gcagggcagc cactgtccgg gatgccgtct 240  
tcattaccgg gctacttget gttacgtcgg cttgaccatc gtccactgga tcaagacggt 300  
30 atcaaagggt tgattccagc agatgaagcg gtgggtgaag cacgtcgcg gtgcctttc 360  
ggcaggggca atatcgacgt ggatgcgcaa cgctccaact tggaaagcgg agcccgccaca 420  
ctcgcggtta ggcgtttgag aaaagatgcc gagggccgcg gtcacgaacc aatgcctgca 480  
aatgaagata tgaactggca tgttcttggt gcgatgtcag gacaggtttt tggcgcgagg 540  
aactgcgggg aacatgcccg catagcgagt ttgcgctacg gtgcactggc tcaggaaaaa 600  
35 gggcggaacg ccgatgagac tattcatttg gctgcgcaac gcggtaaaga ccacgtctgg 660  
gctgaaacgg acaattcaag cgctggatct tcaccggttg tcatggatcc gtggtcgaac 720  
ggtcctgccca tttttgcgga ggatagtcgg tttgccaaag atcgaagtac ggtagaacga 780  
acggattcct tcacgcttgc aactgctgct gaagcaggca agatcacgcg agagacggcc 840  
gagaatgctt tgacacaggc gaccagccgt ttgcagaaac gtcttgctga tcagaaaacg 900  
40 caagtctcgc cgcttgacgg agggcgctat cggcaagaaa attcgggtgct tgatgacgcg 960  
ttcgcgccgac gggcaagtgg caagttgagc aacaaggatc cgcggcatgc attacaggtg 1020  
gaaatcgagg cggccgcagt tgcaatgtcg ctgggcgccc aaggcgtaaa agcggttgcg 1080  
gaacaggccc ggacggtagt tgaacaagcc aggaaggtcg catctcccca aggcacgcct 1140  
45 cagcgagata cgtga 1155

The encoded AvrPphE homolog has an amino acid sequence according to SEQ. ID.  
No. 54 as follows:

50 Met Lys Ile His Asn Ala Gly Pro Ser Ile Pro Met Pro Ala Pro Ser  
1 5 10 15

Ile Glu Ser Ala Gly Lys Thr Ala Gln Ser Ser Leu Ala Gln Pro Gln  
20 25 30

55 Ser Gln Arg Ala Thr Pro Val Ser Pro Ser Glu Thr Ser Asp Ala Arg  
35 40 45

60 Pro Ser Ser Val Arg Thr Asn Tyr Pro Tyr Ser Ser Val Lys Thr Arg  
50 55 60

	Leu	Pro	Pro	Val	Ala	Ser	Ala	Gly	Gln	Pro	Leu	Ser	Gly	Met	Pro	Ser	
	65					70					75					80	
5	Ser	Leu	Pro	Gly	Tyr	Leu	Leu	Leu	Arg	Arg	Leu	Asp	His	Arg	Pro	Leu	
					85					90					95		
	Asp	Gln	Asp	Gly	Ile	Lys	Gly	Leu	Ile	Pro	Ala	Asp	Glu	Ala	Val	Gly	
				100					105					110			
10	Glu	Ala	Arg	Arg	Ala	Leu	Pro	Phe	Gly	Arg	Gly	Asn	Ile	Asp	Val	Asp	
			115					120					125				
	Ala	Gln	Arg	Ser	Asn	Leu	Glu	Ser	Gly	Ala	Arg	Thr	Leu	Ala	Ala	Arg	
15			130				135					140					
	Arg	Leu	Arg	Lys	Asp	Ala	Glu	Ala	Ala	Gly	His	Glu	Pro	Met	Pro	Ala	
	145				150						155					160	
20	Asn	Glu	Asp	Met	Asn	Trp	His	Val	Leu	Val	Ala	Met	Ser	Gly	Gln	Val	
					165					170					175		
	Phe	Gly	Ala	Gly	Asn	Cys	Gly	Glu	His	Ala	Arg	Ile	Ala	Ser	Phe	Ala	
				180					185					190			
25	Tyr	Gly	Ala	Leu	Ala	Gln	Glu	Lys	Gly	Arg	Asn	Ala	Asp	Glu	Thr	Ile	
			195					200					205				
	His	Leu	Ala	Ala	Gln	Arg	Gly	Lys	Asp	His	Val	Trp	Ala	Glu	Thr	Asp	
30			210				215					220					
	Asn	Ser	Ser	Ala	Gly	Ser	Ser	Pro	Val	Val	Met	Asp	Pro	Trp	Ser	Asn	
	225					230					235					240	
35	Gly	Pro	Ala	Ile	Phe	Ala	Glu	Asp	Ser	Arg	Phe	Ala	Lys	Asp	Arg	Ser	
					245					250					255		
	Thr	Val	Glu	Arg	Thr	Asp	Ser	Phe	Thr	Leu	Ala	Thr	Ala	Ala	Glu	Ala	
				260					265					270			
40	Gly	Lys	Ile	Thr	Arg	Glu	Thr	Ala	Glu	Asn	Ala	Leu	Thr	Gln	Ala	Thr	
			275					280					285				
	Ser	Arg	Leu	Gln	Lys	Arg	Leu	Ala	Asp	Gln	Lys	Thr	Gln	Val	Ser	Pro	
45			290				295					300					
	Leu	Ala	Gly	Gly	Arg	Tyr	Arg	Gln	Glu	Asn	Ser	Val	Leu	Asp	Asp	Ala	
	305					310				315						320	
50	Phe	Ala	Arg	Arg	Ala	Ser	Gly	Lys	Leu	Ser	Asn	Lys	Asp	Pro	Arg	His	
					325					330					335		
	Ala	Leu	Gln	Val	Glu	Ile	Glu	Ala	Ala	Ala	Val	Ala	Met	Ser	Leu	Gly	
				340				345						350			
55	Ala	Gln	Gly	Val	Lys	Ala	Val	Ala	Glu	Gln	Ala	Arg	Thr	Val	Val	Glu	
			355					360					365				
	Gln	Ala	Arg	Lys	Val	Ala	Ser	Pro	Gln	Gly	Thr	Pro	Gln	Arg	Asp	Thr	
60			370				375					380					

1000-445660

A DNA molecule from *Pseudomonas syringae* pv. *delphinii* strain PDDCC529 which encodes a homolog of *P. syringae* pv. tomato DC3000 EEL ORF2 has a nucleotide sequence (SEQ. ID. No. 55) as follows:

```

5  gtgggtgagc gaaccggcac tgcataatcga aggcgtggag cagcctgctc gcgtatcacg 60
   agccaaaatc aggtccgacg acgcttttga attacggtga atcagatgca aaagacgtcc 120
   ctattggctt tggcctttgc aatccctggca ggggtgtgggg gttcggggca ggcgccgggg 180
   agtgatatc aggggtgccc gccagagatg aaaacaccca ttaaagtaga tctggatgcc 240
   tacacctcaa aaaaacttga tgctgtgttg gaagctcggg ccaataaaaag ctatgtgaat 300
10 aaaggtcaac tgatcgacct tgtgtcaggg gcgttttttg gaacaccgta ccgctcaaac 360
   atgttggtgg gcacagagga aatacctgaa cagttagtca tgcactttag aggtctggat 420
   tgttttgctt atctggatta cgtagaggcg ttgcgaagat caacatcgca gcaggatttt 480
   gtgaggaatc tcgttcaggt tcgttacaag ggtggtgatg ttgacttttt gaatcgcaag 540
   cactttttca cggattgggc ttatggcact acacaccggg tggcggatga catcaccacg 600
15 cagataagcc ccggtgcggg aagtgtcaga aaacgcctta atgaaagggc caaaggcaaa 660
   gtctatctgc caggtttgcc tgtggttgag cgcagcatga cctatatccc gagccgcctt 720
   gtgcacagtc aggtggtaag ccacttgccg acaggtgatt acatcggcat ttacaccccg 780
   cttcccgggc tggatgtgac gcacgtcggg ttctttatca tgacggataa aggccctgtc 840
   ttgcgaaatg catcttcacg aaaagaaaac agaaaggtaa tggatttgcc ttttctggac 900
20 tatgtatcgg aaaagccagg gattgtgtgt ttcagggcaa aagacaattg a          951

```

The encoded protein or polypeptide has an amino acid sequence according to SEQ. ID. No. 56 as follows:

```

25  Val Val Glu Arg Thr Gly Thr Ala Tyr Arg Arg Arg Gly Ala Ala Cys
     1           5           10          15

30  Ser Arg Ile Thr Ser Gln Asn Gln Val Arg Arg Arg Phe Gly Ile Thr
     20          25          30

   Val Asn Gln Met Gln Lys Thr Ser Leu Leu Ala Leu Ala Phe Ala Ile
     35          40          45

35  Leu Ala Gly Cys Gly Gly Ser Gly Gln Ala Pro Gly Ser Asp Ile Gln
     50          55          60

   Gly Ala Gln Ala Glu Met Lys Thr Pro Ile Lys Val Asp Leu Asp Ala
     65          70          75          80

40  Tyr Thr Ser Lys Lys Leu Asp Ala Val Leu Glu Ala Arg Ala Asn Lys
     85          90          95

   Ser Tyr Val Asn Lys Gly Gln Leu Ile Asp Leu Val Ser Gly Ala Phe
     100         105         110

   Leu Gly Thr Pro Tyr Arg Ser Asn Met Leu Val Gly Thr Glu Glu Ile
     115         120         125

50  Pro Glu Gln Leu Val Ile Asp Phe Arg Gly Leu Asp Cys Phe Ala Tyr
     130         135         140

   Leu Asp Tyr Val Glu Ala Leu Arg Arg Ser Thr Ser Gln Gln Asp Phe
     145         150         155         160

55  Val Arg Asn Leu Val Gln Val Arg Tyr Lys Gly Gly Asp Val Asp Phe
     165         170         175

   Leu Asn Arg Lys His Phe Phe Thr Asp Trp Ala Tyr Gly Thr Thr His
     180         185         190

```

Pro Val Ala Asp Asp Ile Thr Thr Gln Ile Ser Pro Gly Ala Val Ser  
195 200 205

5 Val Arg Lys Arg Leu Asn Glu Arg Ala Lys Gly Lys Val Tyr Leu Pro  
210 215 220

Gly Leu Pro Val Val Glu Arg Ser Met Thr Tyr Ile Pro Ser Arg Leu  
225 230 235 240

10 Val Asp Ser Gln Val Val Ser His Leu Arg Thr Gly Asp Tyr Ile Gly  
245 250 255

Ile Tyr Thr Pro Leu Pro Gly Leu Asp Val Thr His Val Gly Phe Phe  
15 260 265 270

Ile Met Thr Asp Lys Gly Pro Val Leu Arg Asn Ala Ser Ser Arg Lys  
275 280 285

20 Glu Asn Arg Lys Val Met Asp Leu Pro Phe Leu Asp Tyr Val Ser Glu  
290 295 300

Lys Pro Gly Ile Val Val Phe Arg Ala Lys Asp Asn  
25 305 310 315

A DNA molecule from *Pseudomonas syringae* pv. *delphinii* strain

PDDCC529 ORF1 encodes a homolog of AvrPphF and has a nucleotide sequence  
(SEQ. ID. No. 57) as follows:

30 atgaaaaact catttgatct tcttgtcgac ggtttggcga aagactacag catgccgaat 60  
ttgccgaaca agaaacacga caatgaagtc tattgcttca cattccagag cgggctcgaa 120  
gtaaacattt atcaggacga ctgtcgatgg gtgcatttct ccgccacaat cggacaattt 180  
caagacgcca gcaatgacac gtcagccac gcacttcaac tgaacaattt cagtcttggg 240  
35 aagcccttct tcaccttgg aatgaacgga gaaaaggctg gcgtacttca cacacgcgtt 300  
ccgttgattg aaatgaatac cgttgaaatg cgcaaggat tgcaggactt gtcgatgta 360  
gcagggcgga tcagagcgac attcaagctc agttaa 396

40 The encoded AvrPphF homolog has an amino acid sequence according to SEQ. ID.  
No. 58 as follows:

Met Lys Asn Ser Phe Asp Leu Leu Val Asp Gly Leu Ala Lys Asp Tyr  
1 5 10 15

45 Ser Met Pro Asn Leu Pro Asn Lys Lys His Asp Asn Glu Val Tyr Cys  
20 25 30

Phe Thr Phe Gln Ser Gly Leu Glu Val Asn Ile Tyr Gln Asp Asp Cys  
35 40 45

Arg Trp Val His Phe Ser Ala Thr Ile Gly Gln Phe Gln Asp Ala Ser  
50 55 60

55 Asn Asp Thr Leu Ser His Ala Leu Gln Leu Asn Asn Phe Ser Leu Gly  
65 70 75 80

Lys Pro Phe Phe Thr Phe Gly Met Asn Gly Glu Lys Val Gly Val Leu  
85 90 95

60

His Thr Arg Val Pro Leu Ile Glu Met Asn Thr Val Glu Met Arg Lys  
100 105 110  
Val Phe Glu Asp Leu Leu Asp Val Ala Gly Gly Ile Arg Ala Thr Phe  
115 120 125  
Lys Leu Ser  
130

10

A DNA molecule from *Pseudomonas syringae* pv. *delphinii* strain  
PDDCC529 ORF1 encodes a homolog of AvrPphF and has a nucleotide sequence  
(SEQ. ID. No. 59) as follows:

15 atgagtacta tacctggcac ctcgggcgct caccgattt atagctcaat ttccagccca 60  
cgaaatatgt ctggctcgcc cacaccgagt caccgtattg gcggggaaac cctgacctct 120  
attcatcagc tctctgccag ccagagagaa caatttctga atactcatga ccccatgaga 180  
aaactcagga ttaacaatga tacgccactg tacagaacaa ccgagaagcg ttttatacag 240  
20 gaaggcaaac tggccggcaa tccaaagtct attgcacgtg tcaacttgca cgaagaactg 300  
cagcttaatc cgctcgccag tattttaggg aacttacctc acgaggcaag cgcttacttt 360  
ccgaaaagcg cccgcgctgc ggatctgaaa gacccttcat tgaatgtaat gacaggctct 420  
cgggcaaaaa atgctattcg cggctacgct catgacgacc atgtggcggt caagatgcga 480  
ctgggcgact ttcttgaaaa agcgggcaag gtgtacgcgg acacttcac agtcattgac 540  
ggcggagacg aggcgagcgc gctgatcggt acattgccta aaggacaaaa agttccagtc 600  
25 gagattatcc ctacccataa cgacaacagc aataaaggca gaggtcga 648

The encoded AvrPphF homolog has an amino acid sequence according to SEQ. ID.  
No. 60 as follows:

30

Met Ser Thr Ile Pro Gly Thr Ser Gly Ala His Pro Ile Tyr Ser Ser  
1 5 10 15  
Ile Ser Ser Pro Arg Asn Met Ser Gly Ser Pro Thr Pro Ser His Arg  
20 25 30  
Ile Gly Gly Glu Thr Leu Thr Ser Ile His Gln Leu Ser Ala Ser Gln  
35 40 45  
40 Arg Glu Gln Phe Leu Asn Thr His Asp Pro Met Arg Lys Leu Arg Ile  
50 55 60  
Asn Asn Asp Thr Pro Leu Tyr Arg Thr Thr Glu Lys Arg Phe Ile Gln  
65 70 75 80  
45 Glu Gly Lys Leu Ala Gly Asn Pro Lys Ser Ile Ala Arg Val Asn Leu  
85 90 95  
His Glu Glu Leu Gln Leu Asn Pro Leu Ala Ser Ile Leu Gly Asn Leu  
100 105 110  
Pro His Glu Ala Ser Ala Tyr Phe Pro Lys Ser Ala Arg Ala Ala Asp  
115 120 125  
55 Leu Lys Asp Pro Ser Leu Asn Val Met Thr Gly Ser Arg Ala Lys Asn  
130 135 140  
Ala Ile Arg Gly Tyr Ala His Asp Asp His Val Ala Val Lys Met Arg  
145 150 155 160  
60

Leu Gly Asp Phe Leu Glu Lys Gly Gly Lys Val Tyr Ala Asp Thr Ser  
165 170 175  
5 Ser Val Ile Asp Gly Gly Asp Glu Ala Ser Ala Leu Ile Val Thr Leu  
180 185 190  
Pro Lys Gly Gln Lys Val Pro Val Glu Ile Ile Pro Thr His Asn Asp  
195 200 205  
10 Asn Ser Asn Lys Gly Arg Gly  
210 215

A DNA molecule from *Pseudomonas syringae* pv. *syringae* strain

15 226 encodes a homolog of HopPsyA and has a nucleotide sequence (SEQ. ID.  
No. 61) as follows:

gtgaacccta tccatgcacg cttctccagc gtagaagcgc tcagacattc aaacgttgat 60  
attcaggcaa tcaaatccga gggtcagttg gaagtcaacg gcaagcggtta cgagattcgt 120  
20 gcggccgctg acggctcaat cgcggctctc agacccgatc aacagtccaa agcagacaag 180  
ttcttcaaag gcgcagcgca tcttattggc ggacaaagcc agcgtgcccc aatagcccag 240  
gtactcaacg agaaagcggc ggcagttcca cgcctggaca gaatgttggg cagacgcttc 300  
gatctggaga agggcgggaag tagcgctgtg ggcgcgcaa tcaaggctgc cgacagccga 360  
ctgacatcaa aacagacatt tgccagcttc cagcaatggg ctgaaaaagc tgaggcgctc 420  
25 gggcgcgata ccgaaatcgg tatctacatg atctacaaga gggacacgcc agacacaacg 480  
cctatgaatg cggcagagca agaacattac ctggaaacgc tacaggctct cgataacaag 540  
aaaaacctta tcatacgccc gcagatccat gatgatcggg aagaggaaga gcttgatctg 600  
ggccgataca tcgctgaaga cagaaatgcc agaaccggct tttttagaat ggttcctaaa 660  
gaccaacgcg cacctgagac aaactcggga cgacttacca ttggtgtaga acctaaatat 720  
30 ggagcgcagt tggccctcgc aatggcaacc ctgatggaca agcacaaatc tgtgacacaa 780  
ggtaaagtgc tcggtcgggc aaaatatggc cagcaaaactg actctgccat tctttacata 840  
aatggtgatc ttgcaaaagc agtaaaactg ggcgaaaagc tgaaaaagct gagcggatatc 900  
cctctgaag gattcgtoga acatacacgc ctaagcatgc agtcgacggg tctcggctctt 960  
tcttatgcg agtcggttga agggcagcct tccagccacg gacagggcag aacacacggt 1020  
35 atcatggatg ccttgaaagg ccagggcccc atggagaaca gactcaaaat ggcgctggca 1080  
gaaagaggct atgaccgga aaatccggcg ctcagggcgc gaaactga 1128

The encoded HopPsyA homolog has an amino acid sequence according to SEQ. ID.

40 No. 62 as follows:

Val Asn Pro Ile His Ala Arg Phe Ser Ser Val Glu Ala Leu Arg His  
1 5 10 15  
45 Ser Asn Val Asp Ile Gln Ala Ile Lys Ser Glu Gly Gln Leu Glu Val  
20 25 30  
Asn Gly Lys Arg Tyr Glu Ile Arg Ala Ala Asp Gly Ser Ile Ala  
35 40 45  
50 Val Leu Arg Pro Asp Gln Gln Ser Lys Ala Asp Lys Phe Phe Lys Gly  
50 55 60  
55 Ala Ala His Leu Ile Gly Gly Gln Ser Gln Arg Ala Gln Ile Ala Gln  
65 70 75 80  
Val Leu Asn Glu Lys Ala Ala Ala Val Pro Arg Leu Asp Arg Met Leu  
85 90 95

Gly Arg Arg Phe Asp Leu Glu Lys Gly Gly Ser Ser Ala Val Gly Ala  
 100 105 110  
 5 Ala Ile Lys Ala Ala Asp Ser Arg Leu Thr Ser Lys Gln Thr Phe Ala  
 115 120 125  
 Ser Phe Gln Gln Trp Ala Glu Lys Ala Glu Ala Leu Gly Arg Asp Thr  
 130 135 140  
 10 Glu Ile Gly Ile Tyr Met Ile Tyr Lys Arg Asp Thr Pro Asp Thr Thr  
 145 150 155 160  
 Pro Met Asn Ala Ala Glu Gln Glu His Tyr Leu Glu Thr Leu Gln Ala  
 165 170 175  
 15 Leu Asp Asn Lys Lys Asn Leu Ile Ile Arg Pro Gln Ile His Asp Asp  
 180 185 190  
 20 Arg Glu Glu Glu Glu Leu Asp Leu Gly Arg Tyr Ile Ala Glu Asp Arg  
 195 200 205  
 Asn Ala Arg Thr Gly Phe Phe Arg Met Val Pro Lys Asp Gln Arg Ala  
 210 215 220  
 25 Pro Glu Thr Asn Ser Gly Arg Leu Thr Ile Gly Val Glu Pro Lys Tyr  
 225 230 235 240  
 Gly Ala Gln Leu Ala Leu Ala Met Ala Thr Leu Met Asp Lys His Lys  
 245 250 255  
 30 Ser Val Thr Gln Gly Lys Val Val Gly Pro Ala Lys Tyr Gly Gln Gln  
 260 265 270  
 35 Thr Asp Ser Ala Ile Leu Tyr Ile Asn Gly Asp Leu Ala Lys Ala Val  
 275 280 285  
 Lys Leu Gly Glu Lys Leu Lys Lys Leu Ser Gly Ile Pro Pro Glu Gly  
 290 295 300  
 40 Phe Val Glu His Thr Pro Leu Ser Met Gln Ser Thr Gly Leu Gly Leu  
 305 310 315 320  
 Ser Tyr Ala Glu Ser Val Glu Gly Gln Pro Ser Ser His Gly Gln Ala  
 325 330 335  
 45 Arg Thr His Val Ile Met Asp Ala Leu Lys Gly Gln Gly Pro Met Glu  
 340 345 350  
 50 Asn Arg Leu Lys Met Ala Leu Ala Glu Arg Gly Tyr Asp Pro Glu Asn  
 355 360 365  
 Pro Ala Leu Arg Ala Arg Asn  
 370 375  
 55

A DNA molecule from *Pseudomonas syringae* pv. *atrofaciens* strain

B143 encodes a homolog of HopPsyA and has a nucleotide sequence (SEQ. ID.

No. 63) as follows:

60 atgaaccgga tacaacgcg tttctctaac gtcgaagcac ttagacattc agaggtggat 60  
 gtacaggagc tcaaagcaca cggtcaaata gaagtgggtg gcaaattgcta cgacattcgc 120  
 gcggctgccg ataacgacct gactgtccag cgttctgaca aacagatggc gatgagcaag 180

```

5  tttttcaaaa aagcagggtt aagtgggagt tccggcagtc agtccgatca aattgcgcag 240
   gtactgaatg acaagcgcgg ctcttccgtt ccccgcttta tacgccaggg gcagacccat 300
   ctgggcccgtg tgcaattcaa catcgaagag gggcaaggca gttcggccgc cacgtccgtc 360
   cagaacagca ggctgcccga tggccgcttg gtaaacagca gtattttgca atgggtcgaa 420
   aaggcgaaag ccaatggcag cacaagtacc agtgcctttt atcagatcta cgaaaagaa 480
   ctcccgcgtg tagaactgct gccacgcact gagcaccggg cgtgtctggc gcatatgtat 540
   aagctgaacg gtaaggacgg tatcagtatt tggccgcagt ttctggatgg cgtgcgcggg 600
   ttgcagctaa aacatgacac aaaagtgttc atgatgaaca accccaaagc agcggacgag 660
   ttctacaaga tcgaacgttc gggcacgcaa tttccggatg aggctgtcaa ggcgcgcctg 720
10 acgataaatg tcaaacctca attccagaag gccatggtcg acgcagcggc caggttgacc 780
   gctgagcgtc acgatatcat tactgccaaa gtggcagggtc ctgcaaagat tggcacgatt 840
   acagatgcag cgggttttcta tgtaagcggg gattttttccg ctgcgagac acttgcaaaa 900
   gagcttcagg cactgctccc tgacgatgcg tttatcaatc atacgccagc tggaatgcaa 960
   tccatgggca aggggctgtg ttacgccgag cgtacaccgc aggacaggac aagccacgga 1020
15 atgtcgcgcg ccagcataat cgagtcggca ctggcagaca ccagcaggtc gtcactggag 1080
   aagaagctgc gcaatgcttt caagagcgcc ggatacaatc ccgacaaccc ggcattcagg 1140
   ttggaatga                                     1149

```

20 The encoded HopPsyA homolog has an amino acid sequence according to SEQ. ID.  
No. 64 as follows:

```

25 Met Asn Pro Ile Gln Thr Arg Phe Ser Asn Val Glu Ala Leu Arg His
   1 5 10 15
   Ser Glu Val Asp Val Gln Glu Leu Lys Ala His Gly Gln Ile Glu Val
   20 25 30
   Gly Gly Lys Cys Tyr Asp Ile Arg Ala Ala Ala Asn Asn Asp Leu Thr
   35 40 45
   Val Gln Arg Ser Asp Lys Gln Met Ala Met Ser Lys Phe Phe Lys Lys
   50 55 60
35 Ala Gly Leu Ser Gly Ser Ser Gly Ser Gln Ser Asp Gln Ile Ala Gln
   65 70 75 80
   Val Leu Asn Asp Lys Arg Gly Ser Ser Val Pro Arg Leu Ile Arg Gln
   85 90 95
40 Gly Gln Thr His Leu Gly Arg Met Gln Phe Asn Ile Glu Glu Gly Gln
   100 105 110
   Gly Ser Ser Ala Ala Thr Ser Val Gln Asn Ser Arg Leu Pro Asn Gly
   115 120 125
45 Arg Leu Val Asn Ser Ser Ile Leu Gln Trp Val Glu Lys Ala Lys Ala
   130 135 140
   Asn Gly Ser Thr Ser Thr Ser Ala Leu Tyr Gln Ile Tyr Ala Lys Glu
   145 150 155 160
   Leu Pro Arg Val Glu Leu Leu Pro Arg Thr Glu His Arg Ala Cys Leu
   165 170 175
55 Ala His Met Tyr Lys Leu Asn Gly Lys Asp Gly Ile Ser Ile Trp Pro
   180 185 190
   Gln Phe Leu Asp Gly Val Arg Gly Leu Gln Leu Lys His Asp Thr Lys
   195 200 205
60 Val Phe Met Met Asn Asn Pro Lys Ala Ala Asp Glu Phe Tyr Lys Ile
   210 215 220

```

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Glu Arg Ser Gly Thr Gln Phe Pro Asp Glu Ala Val Lys Ala Arg Leu  
 225 230 235 240  
 5 Thr Ile Asn Val Lys Pro Gln Phe Gln Lys Ala Met Val Asp Ala Ala  
 245 250 255  
 Val Arg Leu Thr Ala Glu Arg His Asp Ile Ile Thr Ala Lys Val Ala  
 260 265 270  
 10 Gly Pro Ala Lys Ile Gly Thr Ile Thr Asp Ala Ala Val Phe Tyr Val  
 275 280 285  
 Ser Gly Asp Phe Ser Ala Ala Gln Thr Leu Ala Lys Glu Leu Gln Ala  
 15 290 295 300  
 Leu Leu Pro Asp Asp Ala Phe Ile Asn His Thr Pro Ala Gly Met Gln  
 305 310 315 320  
 20 Ser Met Gly Lys Gly Leu Cys Tyr Ala Glu Arg Thr Pro Gln Asp Arg  
 325 330 335  
 Thr Ser His Gly Met Ser Arg Ala Ser Ile Ile Glu Ser Ala Leu Ala  
 340 345 350  
 25 Asp Thr Ser Arg Ser Ser Leu Glu Lys Lys Leu Arg Asn Ala Phe Lys  
 355 360 365  
 Ser Ala Gly Tyr Asn Pro Asp Asn Pro Ala Phe Arg Leu Glu  
 30 370 375 380

A DNA molecule from *Pseudomonas syringae* pv. *tomato* strain

DC3000 encodes a homolog of HopPtoA, identified herein as HopPtoA2, and has a

35 nucleotide sequence (SEQ. ID. No. 65) as follows:

atgcacatca accaatccgc ccaacaaccg cctggcggtg caatggagag ttttcggaca 60  
 gcttccgacg cgtcccttgc ttcgagttct gtgcggtctg tcagcactac ctctgcccgc 120  
 gatctacaag ctattaccga ttatctgaaa catcacgtgt tcgctgcgca cagggttttcg 180  
 40 gtaataggct caccggatga gcgtgatgcc gctcttgcac acaacgagca gatcgatgcg 240  
 ttggtagaga cacgcgccaa ccgcctgtac tccgaagggg agacccccgc aaccatcgcc 300  
 gaaacattcg ccaaggcgga aaagtctcgc cgtttggcga cgaccgcac aagtgccttt 360  
 gagaacacgc catttgccgc tgcctcggtg ctccagtaca tgcagcctgc gatcaacaag 420  
 ggcgattggc tagcaacgcc gctcaagccg ctgacccccg tcatttccgg agcgctgtcg 480  
 45 ggagccatgg accaggtggg caccaaaatg atggatcggt cgaggggtga tctgcattac 540  
 ctgagcactt cgcgggacaa gttgcatgat gcgatggccg tctcggtgaa gcgccactcg 600  
 cctgcgcttg gtcgacaggt tgtggacatg gggattgcag tgcagacggt ctcggcgcta 660  
 aatgtggtgc gtaccgtatt ggctccagca ctacggtcca gaccgtcggt gcaggggtgct 720  
 gttgattttg gcgtatctac ggcgggtggc ttggttgcca atgcaggctt tggcgaccgc 780  
 50 atgctcagtg tgcaatcgcg cgatcaactg cgtggggggg cattcgtaact tggcatgaaa 840  
 gataaaagag ccaaggccgc gttgagttaa gaaactgatt ggcttgatgc ttacaaaagcg 900  
 atcaagtccg ccagctactc aggtgcggcg ctcaatgcgg gcaagcggat gcccggcctg 960  
 ccaactggacg tcgcgaccga cgggtcgaag gcggtgagaa gtctggtgtc ggccaccagc 1020  
 ctgacaaaaa atggcctggc cctagccggg ggttacgccg gggtaagtaa gttgcagaaa 1080  
 55 atggcgacga aaaatatcac tgattcggcg accaaggctg cggttagtca gctgagcaac 1140  
 ctggtgggtt cggtaggcgt tttcgcaggc tggaccaccg ctggactggc gactgaccct 1200  
 gcggttaaga aagccgagtc gtttatacag gataaggatg aatcgaccgc atctagacc 1260  
 acaagctatg ttgcccacca gaccgtcaaa ctggcgaaaa cagtcaagga catgagcggg 1320  
 gaggcgatct ccagcaccgg tgccagctta cgcagtaact tcaataacct gcgtcatcgc 1380  
 60 tccgctccgg aagctgatat cgaagaaggg gggatttcgg cgtttttctc aagtgaacaa 1440  
 ccgtttcagc tcaggcggtt gtaa 1464

Although *hopPtoA2* does not lie within the CEL, it is included here as a homolog of *hopPtoA*, which corresponds to CEL *ORF5* as noted above. The encoded HopPtoA2 protein or polypeptide has an amino acid sequence according to SEQ.

ID. No. 66 as follows:

5 Met His Ile Asn Gln Ser Ala Gln Gln Pro Pro Gly Val Ala Met Glu  
1 5 10 15

10 Ser Phe Arg Thr Ala Ser Asp Ala Ser Leu Ala Ser Ser Ser Val Arg  
20 25 30

Ser Val Ser Thr Thr Ser Cys Arg Asp Leu Gln Ala Ile Thr Asp Tyr  
35 40 45

15 Leu Lys His His Val Phe Ala Ala His Arg Phe Ser Val Ile Gly Ser  
50 55 60

Pro Asp Glu Arg Asp Ala Ala Leu Ala His Asn Glu Gln Ile Asp Ala  
65 70 75 80

20 Leu Val Glu Thr Arg Ala Asn Arg Leu Tyr Ser Glu Gly Glu Thr Pro  
85 90 95

Ala Thr Ile Ala Glu Thr Phe Ala Lys Ala Glu Lys Phe Asp Arg Leu  
100 105 110

25 Ala Thr Thr Ala Ser Ser Ala Phe Glu Asn Thr Pro Phe Ala Ala Ala  
115 120 125

30 Ser Val Leu Gln Tyr Met Gln Pro Ala Ile Asn Lys Gly Asp Trp Leu  
130 135 140

Ala Thr Pro Leu Lys Pro Leu Thr Pro Leu Ile Ser Gly Ala Leu Ser  
145 150 155 160

35 Gly Ala Met Asp Gln Val Gly Thr Lys Met Met Asp Arg Ala Arg Gly  
165 170 175

Asp Leu His Tyr Leu Ser Thr Ser Pro Asp Lys Leu His Asp Ala Met  
180 185 190

40 Ala Val Ser Val Lys Arg His Ser Pro Ala Leu Gly Arg Gln Val Val  
195 200 205

45 Asp Met Gly Ile Ala Val Gln Thr Phe Ser Ala Leu Asn Val Val Arg  
210 215 220

Thr Val Leu Ala Pro Ala Leu Ala Ser Arg Pro Ser Val Gln Gly Ala  
225 230 235 240

50 Val Asp Phe Gly Val Ser Thr Ala Gly Gly Leu Val Ala Asn Ala Gly  
245 250 255

Phe Gly Asp Arg Met Leu Ser Val Gln Ser Arg Asp Gln Leu Arg Gly  
260 265 270

55 Gly Ala Phe Val Leu Gly Met Lys Asp Lys Glu Pro Lys Ala Ala Leu  
275 280 285

60 Ser Glu Glu Thr Asp Trp Leu Asp Ala Tyr Lys Ala Ile Lys Ser Ala  
290 295 300

Ser Tyr Ser Gly Ala Ala Leu Asn Ala Gly Lys Arg Met Ala Gly Leu  
305 310 315 320

5 Pro Leu Asp Val Ala Thr Asp Gly Leu Lys Ala Val Arg Ser Leu Val  
325 330 335

Ser Ala Thr Ser Leu Thr Lys Asn Gly Leu Ala Leu Ala Gly Gly Tyr  
340 345 350

10 Ala Gly Val Ser Lys Leu Gln Lys Met Ala Thr Lys Asn Ile Thr Asp  
355 360 365

Ser Ala Thr Lys Ala Ala Val Ser Gln Leu Ser Asn Leu Val Gly Ser  
370 375 380

15 Val Gly Val Phe Ala Gly Trp Thr Thr Ala Gly Leu Ala Thr Asp Pro  
385 390 395 400

20 Ala Val Lys Lys Ala Glu Ser Phe Ile Gln Asp Lys Val Lys Ser Thr  
405 410 415

Ala Ser Ser Thr Thr Ser Tyr Val Ala Asp Gln Thr Val Lys Leu Ala  
420 425 430

25 Lys Thr Val Lys Asp Met Ser Gly Glu Ala Ile Ser Ser Thr Gly Ala  
435 440 445

Ser Leu Arg Ser Thr Val Asn Asn Leu Arg His Arg Ser Ala Pro Glu  
450 455 460

30 Ala Asp Ile Glu Glu Gly Gly Ile Ser Ala Phe Ser Arg Ser Glu Thr  
465 470 475 480

35 Pro Phe Gln Leu Arg Arg Leu  
485

Fragments of the above-identified proteins or polypeptides as well as  
fragments of full length proteins from the EELs and CELs of other bacteria, in  
particular Gram-negative pathogens, can also be used according to the present  
invention.

Suitable fragments can be produced by several means. Subclones of  
the gene encoding a known protein can be produced using conventional molecular  
genetic manipulation for subcloning gene fragments, such as described by Sambrook  
et al., 1989, and Ausubel et al., 1994. The subclones then are expressed *in vitro* or *in*  
*vivo* in bacterial cells to yield a smaller protein or polypeptide that can be tested for  
activity, e.g., as a product required for pathogen virulence.

In another approach, based on knowledge of the primary structure of  
the protein, fragments of the protein-coding gene may be synthesized using the PCR  
technique together with specific sets of primers chosen to represent particular portions  
of the protein (Erlich et al., 1991). These can then be cloned into an appropriate

vector for expression of a truncated protein or polypeptide from bacterial cells as described above.

As an alternative, fragments of a protein can be produced by digestion of a full-length protein with proteolytic enzymes like chymotrypsin or *Staphylococcus* proteinase A, or trypsin. Different proteolytic enzymes are likely to cleave different proteins at different sites based on the amino acid sequence of the particular protein. Some of the fragments that result from proteolysis may be active virulence proteins or polypeptides.

Chemical synthesis can also be used to make suitable fragments. Such a synthesis is carried out using known amino acid sequences for the polypeptide being produced. Alternatively, subjecting a full length protein to high temperatures and pressures will produce fragments. These fragments can then be separated by conventional procedures (e.g., chromatography, SDS-PAGE).

Variants may also (or alternatively) be modified by, for example, the deletion or addition of amino acids that have minimal influence on the properties, secondary structure and hydrophobic nature of the polypeptide. For example, a polypeptide may be conjugated to a signal (or leader) sequence at the N-terminal end of the protein which co-translationally or post-translationally directs transfer of the protein. The polypeptide may also be conjugated to a linker or other sequence for ease of synthesis, purification, or identification of the polypeptide.

The proteins or polypeptides used in accordance with the present invention are preferably produced in purified form (preferably at least about 80%, more preferably 90%, pure) by conventional techniques. Typically, the protein or polypeptide of the present invention is secreted into the growth medium of recombinant host cells (discussed *infra*). Alternatively, the protein or polypeptide of the present invention is produced but not secreted into growth medium. In such cases, to isolate the protein, the host cell (e.g., *E. coli*) carrying a recombinant plasmid is propagated, lysed by sonication, heat, or chemical treatment, and the homogenate is centrifuged to remove bacterial debris. The supernatant is then subjected to sequential ammonium sulfate precipitation. The fraction containing the protein or polypeptide of interest is subjected to gel filtration in an appropriately sized dextran

or polyacrylamide column to separate the proteins. If necessary, the protein fraction may be further purified by HPLC.

DNA molecules encoding other EEL and CEL protein or polypeptides can be identified using a PCR-based methodology for cloning portions of the pathogenicity islands of a bacterium. Basically, the PCR-based strategy involves the use of conserved sequences from the *hrpK* and *tRNA<sup>leu</sup>* genes (or other conserved border sequences) as primers for cloning EEL intervening regions of the pathogenicity island. As shown in Figures 2B-C, the *hrpK* and *tRNA<sup>leu</sup>* genes are highly conserved among diverse *Pseudomonas syringae* variants. Depending upon the size of EEL, additional primers can be prepared from the originally obtained cDNA sequence, allowing for recovery of clones and walking through the EEL in a step-wise fashion. If full-length coding sequences are not obtained from the PCR steps, contigs can be assembled to prepare full-length coding sequences using suitable restriction enzymes. Similar PCR-based procedures can be used for obtaining clones that encode open reading frames in the CEL. As shown in Figure 3, the CEL of diverse *Pseudomonas syringae* pathovars contain numerous conserved domains. Moreover, known sequences of the *hrp/hrc* domain, *hrpW*, *AvrE*, or *gstA* can be used to prepare primers.

Using the above-described PCR-based methods, a number of DNA sequences were utilized as the source for primers. One such DNA molecule is isolated from the *tRNA<sup>leu</sup>* gene of *Pseudomonas syringae* pv. tomato DC3000, which has a nucleotide sequence (SEQ. ID. No. 67) as follows:

```
gccctgatgg cggaattggt agacgcggcg gattcaaaat ccgttttcga aagaagtggg      60
agttcgattc tccctcgggg caccacca                                         88
```

An additional DNA molecule which can be used to supply suitable primers is from the *tRNA<sup>leu</sup>* gene of *Pseudomonas syringae* pv. *syringae* B728a, which has a nucleotide sequence (SEQ. ID. No. 68) as follows:

```
gccctgatgg cggaattggt agacgcggcg gattcaaaat ccgttttcga aagaagtggg      60
agttcgattc tccctcgggg cacca                                           85
```

Another DNA molecule is isolated from the *queA* gene of *Pseudomonas syringae* pv. tomato DC3000, which has a nucleotide sequence (SEQ. ID. No. 69) as follows:

```

atgcgcgctc ctgactttac cttcgaactc cccgattccc tgattgctcg tcacccggtt 60
gccgagcgtc gcagcagtcg tctgttgacc cttgatgggc cgacgggcgc gctggcacat 120
cgtcaattca ccgatttgct cgagcatttg cgctcgggcg acttgatggt gttcaacaat 180
acccgtgtca ttcccgacg tttgttcggg cagaaggcgt ccggcgcaa gctggagatt 240
5 ctggtcagac gcgtgctgga cagccatcgt gtgctggcgc acgtgcgtgc cagcaagtcg 300
ccaaagccgg gctcgtcgat cctgatcgat ggccggcgcg aggcgagat ggtggcgcg 360
catgacgcgc tgttcgagtt gcgctttgcc gaagaagtgc tgccgttget ggatcgtgtc 420
ggccatatgc cgttgctccc ttatatagac cgcccgacg aaggtgccga ccgcgagcgt 480
10 tatcagaccg tttacgcccc gcgcgcgggt gctgtggcgg cgccgactgc cggcctgcat 540
ttcgaccagc cgttgatgga agcaattgcc gccaaaggcg tcgagactgc ttttgtcact 600
ctgcacgtcg gcgcgggtac gttccagccg gtgctgtgct agcagatcga agatcaccac 660
atgcacagcg aatggctgga agtcagccag gacgtggctc atgccgtggc ggcgtgccc 720
gcgcggggcg ggccgggtgat tgcggtcggg accaccagcg tgcgttcgct ggagagtgc 780
gcgcgtgatg gccagttgaa gccgtttagc ggcgacaccg acatcttcat ctatccgggg 840
15 cgcccgtttc atgtggtcga tgccctggtg actaattttc atttgctcga atccacgctg 900
ttgatgctgg tttcggcggt cgccggttat cccgaaacca tggcggccta cgccggcgcc 960
atcgaacacg ggtaccgctt cttcagttac ggtgatgcca tgttcacac ccgcaatccc 1020
gcgcgcgacg cccacagga atcggcacca gaggatcac catga 1065

```

20

This DNA molecule encodes QueA, which has an amino acid sequence (SEQ. ID. No. 70) as follows:

```

25 Met Arg Val Ala Asp Phe Thr Phe Glu Leu Pro Asp Ser Leu Ile Ala
    1          5          10          15

Arg His Pro Leu Ala Glu Arg Arg Ser Ser Arg Leu Leu Thr Leu Asp
          20          25          30

30 Gly Pro Thr Gly Ala Leu Ala His Arg Gln Phe Thr Asp Leu Leu Glu
    35          40          45

His Leu Arg Ser Gly Asp Leu Met Val Phe Asn Asn Thr Arg Val Ile
    50          55          60

35 Pro Ala Arg Leu Phe Gly Gln Lys Ala Ser Gly Gly Lys Leu Glu Ile
    65          70          75          80

Leu Val Glu Arg Val Leu Asp Ser His Arg Val Leu Ala His Val Arg
    85          90          95

Ala Ser Lys Ser Pro Lys Pro Gly Ser Ser Ile Leu Ile Asp Gly Gly
    100          105          110

45 Gly Glu Ala Glu Met Val Ala Arg His Asp Ala Leu Phe Glu Leu Arg
    115          120          125

Phe Ala Glu Glu Val Leu Pro Leu Leu Asp Arg Val Gly His Met Pro
    130          135          140

50 Leu Pro Pro Tyr Ile Asp Arg Pro Asp Glu Gly Ala Asp Arg Glu Arg
    145          150          155          160

Tyr Gln Thr Val Tyr Ala Gln Arg Ala Gly Ala Val Ala Ala Pro Thr
    165          170          175

55 Ala Gly Leu His Phe Asp Gln Pro Leu Met Glu Ala Ile Ala Ala Lys
    180          185          190

60 Gly Val Glu Thr Ala Phe Val Thr Leu His Val Gly Ala Gly Thr Phe
    195          200          205

```

Gln Pro Val Arg Val Glu Gln Ile Glu Asp His His Met His Ser Glu  
 210 215 220  
 5 Trp Leu Glu Val Ser Gln Asp Val Val Asp Ala Val Ala Ala Cys Arg  
 225 230 235 240  
 Ala Arg Gly Gly Arg Val Ile Ala Val Gly Thr Thr Ser Val Arg Ser  
 245 250 255  
 10 Leu Glu Ser Ala Ala Arg Asp Gly Gln Leu Lys Pro Phe Ser Gly Asp  
 260 265 270  
 Thr Asp Ile Phe Ile Tyr Pro Gly Arg Pro Phe His Val Val Asp Ala  
 275 280 285  
 15 Leu Val Thr Asn Phe His Leu Pro Glu Ser Thr Leu Leu Met Leu Val  
 290 295 300  
 20 Ser Ala Phe Ala Gly Tyr Pro Glu Thr Met Ala Ala Tyr Ala Ala Ala  
 305 310 315 320  
 Ile Glu His Gly Tyr Arg Phe Phe Ser Tyr Gly Asp Ala Met Phe Ile  
 325 330 335  
 25 Thr Arg Asn Pro Ala Pro Thr Ala Pro Gln Glu Ser Ala Pro Glu Asp  
 340 345 350  
 His Ala  
 30

DNA molecules encoding other EEL and CEL proteins or polypeptides  
 can also be identified by determining whether such DNA molecules hybridize under  
 stringent conditions to a DNA molecule as identified above. An example of suitable  
 35 stringency conditions is when hybridization is carried out at a temperature of about  
 37°C using a hybridization medium that includes 0.9M sodium citrate ("SSC") buffer,  
 followed by washing with 0.2x SSC buffer at 37°C. Higher stringency can readily be  
 attained by increasing the temperature for either hybridization or washing conditions  
 or increasing the sodium concentration of the hybridization or wash medium.  
 40 Nonspecific binding may also be controlled using any one of a number of known  
 techniques such as, for example, blocking the membrane with protein-containing  
 solutions, addition of heterologous RNA, DNA, and SDS to the hybridization buffer,  
 and treatment with RNase. Wash conditions are typically performed at or below  
 stringency. Exemplary high stringency conditions include carrying out hybridization  
 45 at a temperature of about 42°C to about 65°C for up to about 20 hours in a  
 hybridization medium containing 1M NaCl, 50 mM Tris-HCl, pH 7.4, 10 mM EDTA,  
 0.1% sodium dodecyl sulfate (SDS), 0.2% ficoll, 0.2% polyvinylpyrrolidone, 0.2%

bovine serum albumin, and 50 µg/ml *E. coli* DNA, followed by washing carried out at between about 42°C to about 65°C in a 0.2x SSC buffer.

Also encompassed by the present invention are nucleic acid molecules which contain conserved substitutions as compared to the above identified DNA  
5 molecules and, thus, encode the same protein or polypeptides identified above. Further, complementary sequences are also encompassed by the present invention.

The nucleic acid of the present invention can be either DNA or RNA, which can readily be prepared using the above identified DNA molecules of the present invention.

10 The delivery of effector proteins or polypeptides can be achieved in several ways, depending upon the host being treated and the materials being used: (1) as a stable or plasmid-encoded transgene; (2) transiently expressed via *Agrobacterium* or viral vectors; (3) delivered by the type III secretion systems of disarmed pathogens or recombinant nonpathogenic bacteria which express a functional, heterologous type  
15 III secretion system; or (4) delivered via topical application followed by TAT protein transduction domain-mediated spontaneous uptake into cells. Each of these is discussed *infra*.

The DNA molecule encoding the protein or polypeptide can be incorporated in cells using conventional recombinant DNA technology. Generally,  
20 this involves inserting the DNA molecule into an expression system to which the DNA molecule is heterologous (i.e. not normally present). The heterologous DNA molecule is inserted into the expression system or vector in proper sense orientation and correct reading frame. The vector contains the necessary elements for the transcription and translation of the inserted protein-coding sequences.

25 U.S. Patent No. 4,237,224 to Cohen and Boyer describes the production of expression systems in the form of recombinant plasmids using restriction enzyme cleavage and ligation with DNA ligase. These recombinant plasmids are then introduced by means of transformation and replicated in unicellular cultures including prokaryotic organisms and eukaryotic cells grown in tissue culture.

30 Recombinant genes may also be introduced into viruses, such as vaccina virus. Recombinant viruses can be generated by transfection of plasmids into cells infected with virus.

Suitable vectors include, but are not limited to, the following viral vectors such as lambda vector system gt11, gt WES.tB, Charon 4, and plasmid vectors such as pBR322, pBR325, pACYC177, pACYC1084, pUC8, pUC9, pUC18, pUC19, pLG339, pR290, pKC37, pKC101, SV 40, pBluescript II SK +/- or KS +/- (see  
5 "Stratagene Cloning Systems" Catalog (1993) from Stratagene, La Jolla, Calif, which is hereby incorporated by reference), pQE, pIH821, pGEX, pET series (see Studier et al., 1990). Recombinant molecules can be introduced into cells via transformation, particularly transduction, conjugation, mobilization, or electroporation. The DNA sequences are cloned into the vector using standard cloning procedures in the art, as  
10 described by Sambrook et al., 1989.

A variety of host-vector systems may be utilized to express the protein-encoding sequence(s). Primarily, the vector system must be compatible with the host cell used. Host-vector systems include, but are not limited to, the following: bacteria transformed with bacteriophage DNA, plasmid DNA, or cosmid DNA;  
15 microorganisms such as yeast containing yeast vectors; mammalian cell systems infected with virus (e.g., vaccinia virus, adenovirus, etc.); insect cell systems infected with virus (e.g., baculovirus); and plant cells infected by bacteria. The expression elements of these vectors vary in their strength and specificities. Depending upon the host-vector system utilized, any one of a number of suitable transcription and  
20 translation elements can be used.

Different genetic signals and processing events control many levels of gene expression (e.g., DNA transcription and messenger RNA (mRNA) translation).

Transcription of DNA is dependent upon the presence of a promoter which is a DNA sequence that directs the binding of RNA polymerase and thereby  
25 promotes mRNA synthesis. The DNA sequences of eukaryotic promoters differ from those of prokaryotic promoters. Eukaryotic promoters and accompanying genetic signals may not be recognized in or may not function in a prokaryotic system and, further, prokaryotic promoters are not recognized and do not function in eukaryotic cells.

30 Similarly, translation of mRNA in prokaryotes depends upon the presence of the proper prokaryotic signals which differ from those of eukaryotes. Efficient translation of mRNA in prokaryotes requires a ribosome binding site called

the Shine-Dalgarno ("SD") sequence on the mRNA. This sequence is a short nucleotide sequence of mRNA that is located before the start codon, usually AUG, which encodes the amino-terminal methionine of the protein. The SD sequences are complementary to the 3'-end of the 16S rRNA (ribosomal RNA) and probably  
5 promote binding of mRNA to ribosomes by duplexing with the rRNA to allow correct positioning of the ribosome. For a review on maximizing gene expression, see Roberts and Lauer, 1979.

Promoters vary in their "strength" (i.e., their ability to promote transcription). For the purposes of expressing a cloned gene, it is desirable to use  
10 strong promoters in order to obtain a high level of transcription and, hence, expression of the gene. Depending upon the host cell system utilized, any one of a number of suitable promoters may be used. For instance, when cloning in *E. coli*, its bacteriophages, or plasmids, promoters such as the T7 phage promoter, *lac* promoter, *trp* promoter, *recA* promoter, ribosomal RNA promoter, the P<sub>R</sub> and P<sub>L</sub> promoters of  
15 coliphage lambda and others, including but not limited, to *lacUV5*, *ompF*, *bla*, *lpp*, and the like, may be used to direct high levels of transcription of adjacent DNA segments. Additionally, a hybrid *trp-lacUV5* (*tac*) promoter or other *E. coli* promoters produced by recombinant DNA or other synthetic DNA techniques may be used to provide for transcription of the inserted gene.

20 Bacterial host cell strains and expression vectors may be chosen which inhibit the action of the promoter unless specifically induced. In certain operations, the addition of specific inducers is necessary for efficient transcription of the inserted DNA. For example, the *lac* operon is induced by the addition of lactose or IPTG (isopropylthio-beta-D-galactoside). A variety of other operons, such as *trp*, *pro*, etc.,  
25 are under different controls.

Specific initiation signals are also required for efficient gene transcription and translation in prokaryotic cells. These transcription and translation initiation signals may vary in "strength" as measured by the quantity of gene specific messenger RNA and protein synthesized, respectively. The DNA expression vector,  
30 which contains a promoter, may also contain any combination of various "strong" transcription and/or translation initiation signals. For instance, efficient translation in *E. coli* requires an SD sequence about 7-9 bases 5' to the initiation codon ("ATG") to

provide a ribosome binding site. Thus, any SD-ATG combination that can be utilized by host cell ribosomes may be employed. Such combinations include but are not limited to the SD-ATG combination from the *cro* gene or the *N* gene of coliphage lambda, or from the *E. coli* tryptophan E, D, C, B or A genes. Additionally, any SD-ATG combination produced by recombinant DNA or other techniques involving  
5 incorporation of synthetic nucleotides may be used.

Once the isolated DNA molecule encoding the polypeptide or protein has been cloned into an expression system, it is ready to be incorporated into a host cell. Such incorporation can be carried out by the various forms of transformation  
10 noted above, depending upon the vector/host cell system. Suitable host cells include, but are not limited to, bacteria, virus, yeast, mammalian cells, insect, plant, and the like.

Because it is desirable for recombinant host cells to secrete the encoded protein or polypeptide, it is preferable that the host cell also possess a  
15 functional type III secretion system. The type III secretion system can be heterologous to host cell (Ham et al., 1998) or the host cell can naturally possess a type III secretion system. Host cells which naturally contain a type III secretion system include many pathogenic Gram-negative bacterium, such as numerous *Erwinia* species, *Pseudomonas* species, *Xanthomonas* species, etc. Other type III  
20 secretion systems are known and still others are continually being identified. Pathogenic bacteria that can be utilized to deliver effector proteins or polypeptides are preferably disarmed according to known techniques, i.e., as described above. Alternatively, isolation of the effector protein or polypeptide from the host cell or growth medium can be carried out as described above.

25 Another aspect of the present invention relates to a transgenic plant which express a protein or polypeptide of the present invention and methods of making the same.

In order to express the DNA molecule in isolated plant cells or tissue or whole plants, a plant expressible promoter is needed. Any plant-expressible  
30 promoter can be utilized regardless of its origin, i.e., viral, bacterial, plant, etc. Without limitation, two suitable promoters include the nopaline synthase promoter (Fraley et al., 1983) and the cauliflower mosaic virus 35S promoter (O'Dell et al.,

1985). Both of these promoters yield constitutive expression of coding sequences under their regulatory control.

While constitutive expression is generally suitable for expression of the DNA molecule, it should be apparent to those of skill in the art that temporally or tissue regulated expression may also be desirable, in which case any regulated promoter can be selected to achieve the desired expression. Typically, the temporally or tissue regulated promoters will be used in connection with the DNA molecule that are expressed at only certain stages of development or only in certain tissues.

In some plants, it may also be desirable to use promoters which are responsive to pathogen infiltration or stress. For example, it may be desirable to limit expression of the protein or polypeptide in response to infection by a particular pathogen of the plant. One example of a pathogen-inducible promoter is the *gstI* promoter from potato, which is described in U.S. Patent Nos. 5,750,874 and 5,723,760 to Strittmayer et al., which are hereby incorporated by reference.

Expression of the DNA molecule in isolated plant cells or tissue or whole plants also requires appropriate transcription termination and polyadenylation of mRNA. Any 3' regulatory region suitable for use in plant cells or tissue can be operably linked to the first and second DNA molecules. A number of 3' regulatory regions are known to be operable in plants. Exemplary 3' regulatory regions include, without limitation, the nopaline synthase 3' regulatory region (Fraley et al., 1983) and the cauliflower mosaic virus 3' regulatory region (Odell et al., 1985).

The promoter and a 3' regulatory region can readily be ligated to the DNA molecule using well known molecular cloning techniques described in Sambrook et al., 1989.

One approach to transforming plant cells with a DNA molecule of the present invention is particle bombardment (also known as biolistic transformation) of the host cell. This can be accomplished in one of several ways. The first involves propelling inert or biologically active particles at cells. This technique is disclosed in U.S. Patent Nos. 4,945,050, 5,036,006, and 5,100,792, all to Sanford, et al.

Generally, this procedure involves propelling inert or biologically active particles at the cells under conditions effective to penetrate the outer surface of the cell and to be incorporated within the interior thereof. When inert particles are utilized, the vector

can be introduced into the cell by coating the particles with the vector containing the heterologous DNA. Alternatively, the target cell can be surrounded by the vector so that the vector is carried into the cell by the wake of the particle. Biologically active particles (e.g., dried bacterial cells containing the vector and heterologous DNA) can also be propelled into plant cells. Other variations of particle bombardment, now known or hereafter developed, can also be used.

Another method of introducing the DNA molecule into plant cells is fusion of protoplasts with other entities, either minicells, cells, lysosomes, or other fusible lipid-surfaced bodies that contain the DNA molecule (Fraley et al., 1982).

The DNA molecule may also be introduced into the plant cells by electroporation (Fromm, et al., 1985). In this technique, plant protoplasts are electroporated in the presence of plasmids containing the DNA molecule. Electrical impulses of high field strength reversibly permeabilize biomembranes allowing the introduction of the plasmids. Electroporated plant protoplasts reform the cell wall, divide, and regenerate.

Another method of introducing the DNA molecule into plant cells is to infect a plant cell with *Agrobacterium tumefaciens* or *Agrobacterium rhizogenes* previously transformed with the DNA molecule. Under appropriate conditions known in the art, the transformed plant cells are grown to form shoots or roots, and develop further into plants. Generally, this procedure involves inoculating the plant tissue with a suspension of bacteria and incubating the tissue for 48 to 72 hours on regeneration medium without antibiotics at 25-28°C.

*Agrobacterium* is a representative genus of the Gram-negative family Rhizobiaceae. Its species are responsible for crown gall (*A. tumefaciens*) and hairy root disease (*A. rhizogenes*). The plant cells in crown gall tumors and hairy roots are induced to produce amino acid derivatives known as opines, which are catabolized only by the bacteria. The bacterial genes responsible for expression of opines are a convenient source of control elements for chimeric expression cassettes. In addition, assaying for the presence of opines can be used to identify transformed tissue.

Heterologous genetic sequences such as a DNA molecule of the present invention can be introduced into appropriate plant cells by means of the Ti plasmid of *A. tumefaciens* or the Ri plasmid of *A. rhizogenes*. The Ti or Ri plasmid

is transmitted to plant cells on infection by *Agrobacterium* and is stably integrated into the plant genome (Schell, 1987).

Plant tissue suitable for transformation include leaf tissue, root tissue, meristems, zygotic and somatic embryos, and anthers.

5 After transformation, the transformed plant cells can be selected and regenerated.

Preferably, transformed cells are first identified using, e.g., a selection marker simultaneously introduced into the host cells along with the DNA molecule of the present invention. Suitable selection markers include, without limitation, markers  
10 coding for antibiotic resistance, such as kanamycin resistance (Fraley et al., 1983). A number of antibiotic-resistance markers are known in the art and other are continually being identified. Any known antibiotic-resistance marker can be used to transform and select transformed host cells in accordance with the present invention. Cells or tissues are grown on a selection media containing an antibiotic, whereby generally  
15 only those transformants expressing the antibiotic resistance marker continue to grow.

Once a recombinant plant cell or tissue has been obtained, it is possible to regenerate a full-grown plant therefrom. Thus, another aspect of the present invention relates to a transgenic plant that includes a DNA molecule of the present invention, wherein the promoter induces transcription of the first DNA molecule in  
20 response to infection of the plant by an oomycete. Preferably, the DNA molecule is stably inserted into the genome of the transgenic plant of the present invention.

Plant regeneration from cultured protoplasts is described in Evans et al., 1983, and Vasil, 1984 and 1986.

It is known that practically all plants can be regenerated from cultured  
25 cells or tissues, including but not limited to, all major species of rice, wheat, barley, rye, cotton, sunflower, peanut, corn, potato, sweet potato, bean, pea, chicory, lettuce, endive, cabbage, cauliflower, broccoli, turnip, radish, spinach, onion, garlic, eggplant, pepper, celery, carrot, squash, pumpkin, zucchini, cucumber, apple, pear, melon, strawberry, grape, raspberry, pineapple, soybean, tobacco, tomato, sorghum, and  
30 sugarcane.

Means for regeneration vary from species to species of plants, but generally a suspension of transformed protoplasts or a petri plate containing

transformed explants is first provided. Callus tissue is formed and shoots may be induced from callus and subsequently rooted. Alternatively, embryo formation can be induced in the callus tissue. These embryos germinate as natural embryos to form plants. The culture media will generally contain various amino acids and hormones, such as auxin and cytokinins. It is also advantageous to add glutamic acid and proline to the medium, especially for such species as corn and alfalfa. Efficient regeneration will depend on the medium, on the genotype, and on the history of the culture. If these three variables are controlled, then regeneration is usually reproducible and repeatable.

After the DNA molecule is stably incorporated in transgenic plants, it can be transferred to other plants by sexual crossing or by preparing cultivars. With respect to sexual crossing, any of a number of standard breeding techniques can be used depending upon the species to be crossed. Cultivars can be propagated in accord with common agricultural procedures known to those in the field.

Diseases caused by the vast majority of bacterial pathogens result in limited lesions. That is, even when everything is working in the pathogen's favor (e.g., no triggering of the hypersensitive response because of *R*-gene detection of one of the effectors), the parasitic process still triggers defenses after a couple of days, which then stops the infection from spreading. Thus, the very same effectors that enable parasitism to proceed must also eventually trigger defenses. Therefore, premature expression of these effectors is believed to "turn on" plant defenses earlier (i.e., prior to infection) and make the plant resistant to either the specific bacteria from which the effector protein was obtained or many pathogens. An advantage of this approach is that it involves natural products and plants seem highly sensitive to pathogen effector proteins.

According to one embodiment, a transgenic plant is provided that contains a heterologous DNA molecule of the present invention. Preferably, the heterologous DNA molecule is derived from a plant pathogen EEL. When the heterologous DNA molecule is expressed in the transgenic plant, plant defenses are activated, imparting disease resistance to the transgenic plant. The transgenic plant can also contain an *R*-gene which is activated by the protein or polypeptide product of the heterologous DNA molecule. The *R* gene can be naturally occurring in the plant

or heterologously inserted therein. A number of R genes have been identified in various plant species, including without limitation: *RPS2*, *RPM1*, and *RPP5* from *Arabidopsis thaliana*; *Cf2*, *Cf9*, *I2*, *Pto*, and *Prf* from tomato; *N* from tobacco; *L6* and *M* from flax; *Xa21* from rice; and *Hs1pro-1* from sugar beet. In addition to imparting disease resistance, it is believed that stimulation of plant defenses in transgenic plants of the present invention will also result in a simultaneous enhancement in growth and resistance to insects.

According to another embodiment, a plant, transgenic or non-transgenic, is treated with a protein or polypeptide of the present invention. By treating, it is intended to include various forms of applying the protein or polypeptide to the plant. The embodiments of the present invention where the effector polypeptide or protein is applied to the plant can be carried out in a number of ways, including: 1) application of an isolated protein (or composition containing the same) or 2) application of bacteria which do not cause disease and are transformed with a gene encoding the effector protein of the present invention. In the latter embodiment, the effector protein can be applied to plants by applying bacteria containing the DNA molecule encoding the effector protein. Such bacteria are preferably capable of secreting or exporting the protein so that the protein can contact plant cells. In these embodiments, the protein is produced by the bacteria *in planta*.

Such topical application is typically carried out using an effector fusion protein which includes a transduction domain, which will afford transduction domain-mediated spontaneous uptake of the effector protein into cells. Basically, this is carried out by fusing an 11-amino acid peptide (YGRKKRRQRRR, SEQ. ID. No. 91) by standard rDNA techniques to the N-terminus of the effector protein, and the resulting tagged protein is taken up into cells by a poorly understood process. This peptide is the protein transduction domain (PTD) of the human immunodeficiency virus (HIV) TAT protein (Schwarze et al., 2000). Other PTDs are known and may possibly be used for this purpose (Prochiantz, 2000).

When the effector protein is topically applied to plants, it can be applied as a composition, which includes a carrier in the form, e.g., of water, aqueous solutions, slurries, or dry powders. In this embodiment, the composition contains greater than about 5 nM of the protein of the present invention.

Although not required, this composition may contain additional additives including fertilizer, insecticide, fungicide, nematocide, and mixtures thereof. Suitable fertilizers include  $(\text{NH}_4)_2\text{NO}_3$ . An example of a suitable insecticide is Malathion. Useful fungicides include Captan.

- 5                    Other suitable additives include buffering agents, wetting agents, coating agents, and, in some instances, abrading agents. These materials can be used to facilitate the process of the present invention.

- 10                   According to another aspect of the present invention, a transgenic plant is provided that contains a heterologous DNA molecule that encodes a transcript or a protein or polypeptide capable of disrupting function of a plant pathogen CEL product. Because the genes in the CEL are particularly important in pathogenesis, disrupting the function of their products in plants can result in broad resistance since CEL genes are highly conserved among Gram negative pathogens, particularly along species lines. An exemplary protein or polypeptide which can disrupt function of a  
15                   CEL product is an antibody, polyclonal or monoclonal, raised against the CEL product using conventional techniques. Once isolated, the antibody can be sequenced and nucleic acids synthesized for encoding the same. Such nucleic acids, e.g., DNA, can be used to transform plants.

- 20                   Transgenic plants can also be engineered so that they are hypersusceptible and, therefore, will support the growth of nonpathogenic bacteria for biotechnological purposes. It is known that many plant pathogenic bacteria can alter the environment inside plant leaves so that nonpathogenic bacteria can grow. This ability is presumably based on changes in the plant caused by pathogen effector proteins. Thus, transgenic plants expressing the appropriate effector genes can be  
25                   used for these purposes.

- 30                   According to one embodiment, a transgenic plant including a heterologous DNA molecule of the present invention expresses one or more effector proteins, wherein the transgenic plant is capable of supporting growth of compatible nonpathogenic bacteria (i.e., non-pathogenic endophytes such as various *Clavibacter* spp.). The compatible nonpathogenic bacteria can be naturally occurring or it can be recombinant. Preferably, the nonpathogenic bacteria is recombinant and expresses one or more useful products. Thus, the transgenic plant becomes a green factory for

producing desirable products. Desirable products include, without limitation, products that can enhance the nutritional quality of the plant or products that are desirable in isolated form. If desired in isolated form, the product can be isolated from plant tissues. To prevent competition between the non-pathogenic bacteria which express the desired product and those that do not, it is possible to tailor the needs of recombinant, non-pathogenic bacteria so that only they are capable of living in plant tissues expressing a particular effector protein or polypeptide of the present invention.

The effector proteins or polypeptides of the present invention are believed to alter the plant physiology by shifting metabolic pathways to benefit the parasite and by activating or suppressing cell death pathways. Thus, they may also provide useful tools for efficiently altering the nutrient content of plants and delaying or triggering senescence. There are agricultural applications for all of these possible effects.

A further aspect of the present invention relates to diagnostic uses of the CEL and EEL. The CEL genes are universal to species of Gram negative bacteria, particularly pathogenic Gram negative bacteria (such as *P. syringae*), whereas the EEL sequences are strain-specific and provide a "virulence gene fingerprint" that could be used to track the presence, origins, and movement (and restrict the spread through quarantines) of strains that are particularly threatening. Although the CEL and EEL have been identified in various pathovars of *Pseudomonas syringae*, it is expected that most all Gram-negative pathogens can be identified, distinguished, and classified based upon the homology of the CEL and EEL genes.

According to one embodiment, a method of determining relatedness between two bacteria is carried out by comparing a nucleic acid alignment or amino acid alignment for a CEL of the two bacteria and then determining the relatedness of the two bacteria, wherein a higher sequence identity indicates a closer relationship. The CEL is particularly useful for determining the relatedness of two distinct bacterial species.

According to another embodiment, a method of determining relatedness between two bacteria which is carried out by comparing a nucleic acid alignment or amino acid alignment for an EEL of the two bacteria and then

determining the relatedness of the two bacteria, wherein a higher sequence identity indicates a closer relationship. The EEL is particularly useful for determining the relatedness of two pathovars of a single bacterial species.

Given the methods of determining relatedness of bacteria species and/or pathovars, these methods can be utilized in conjunction with plant breeding programs. By detecting the “virulence gene fingerprint” of pathogens which are prevalent in a particular growing region, it is possible either to develop transgenic cultivars as described above or to identify existing plant cultivars which are resistant to the prevalent pathogens.

In addition to the above described uses, another aspect of the present invention relates to gene- and protein-based therapies for animals, preferably mammals including, without limitation, humans, dogs, mice, rats. The *P. syringae* pv. *syringae* B728a EEL ORF5 protein (SEQ. ID. No. 32) is a member of the AvrRxv/YopJ protein family. YopJ is injected into human cells by the *Yersinia* type III secretion system, where it disrupts the function of certain protein kinases to inhibit cytokine release and promote programmed cell death. It is believed that the targets of many pathogen effector proteins (i.e., *P. syringae* effector proteins) will be universal to eukaryotes and therefore have a variety of potentially useful functions. In fact, two of the proteins in the *P. syringae* Hrp pathogenicity islands are toxic when expressed in yeast. They are HopPsyA from the *P. syringae* pv. *syringae* EEL and HopPtoA from the *P. syringae* pv. *tomato* DC3000 CEL. This supports the concept of universal eukaryote targets.

Thus, a further aspect of the present invention relates to a method of causing eukaryotic cell death which is carried out by introducing into a eukaryotic cell a cytotoxic *Pseudomonas* protein. The cytotoxic *Pseudomonas* protein is preferably HopPsyA (e.g., SEQ. ID. Nos. 36 (*Psy* 61), 62 (*Psy* 226), or 64 (*Psy* B143)) HopPtoA (SEQ. ID. No. 7), or HopPtoA2 (SEQ. ID. No. 66). The eukaryotic cell which is treated can be either *in vitro* or *in vivo*. When treating eukaryotic cells *in vivo*, a number of different protein- or DNA-delivery systems can be employed to introduce the effector protein into the target eukaryotic cell.

Without being bound by theory, it is believed that at least the HopPsyA effector proteins exert their cytotoxic effects through Mad2 interactions, disrupting cell checkpoint of spindle formation (see *infra*).

The protein- or DNA-delivery systems can be provided in the form of pharmaceutical compositions which include the delivery system in a pharmaceutically acceptable carrier, which may include suitable excipients or stabilizers. The dosage can be in solid or liquid form, such as powders, solutions, suspensions, or emulsions. Typically, the composition will contain from about 0.01 to 99 percent, preferably from about 20 to 75 percent of active compound(s), together with the carrier, excipient, stabilizer, etc.

The compositions of the present invention are preferably administered in injectable or topically-applied dosages by solution or suspension of these materials in a physiologically acceptable diluent with a pharmaceutical carrier. Such carriers include sterile liquids, such as water and oils, with or without the addition of a surfactant and other pharmaceutically and physiologically acceptable carrier, including adjuvants, excipients or stabilizers. Illustrative oils are those of petroleum, animal, vegetable, or synthetic origin, for example, peanut oil, soybean oil, or mineral oil. In general, water, saline, aqueous dextrose and related sugar solution, and glycols, such as propylene glycol or polyethylene glycol, are preferred liquid carriers, particularly for injectable solutions.

Alternatively, the effector proteins can also be delivered via solution or suspension packaged in a pressurized aerosol container together with suitable propellants, for example, hydrocarbon propellants like propane, butane, or isobutane with conventional adjuvants. The materials of the present invention also may be administered in a non-pressurized form such as in a nebulizer or atomizer.

Depending upon the treatment being effected, the compounds of the present invention can be administered orally, topically, transdermally, parenterally, subcutaneously, intravenously, intramuscularly, intraperitoneally, by intranasal instillation, by intracavitary or intravesical instillation, intraocularly, intraarterially, intralesionally, or by application to mucous membranes, such as, that of the nose, throat, and bronchial tubes.

Compositions within the scope of this invention include all compositions wherein the compound of the present invention is contained in an amount effective to achieve its intended purpose. While individual needs vary, determination of optimal ranges of effective amounts of each component is within the skill of the art.

One approach for delivering an effector protein into cells involves the use of liposomes. Basically, this involves providing a liposome which includes that effector protein to be delivered, and then contacting the target cell with the liposome under conditions effective for delivery of the effector protein into the cell.

Liposomes are vesicles comprised of one or more concentrically ordered lipid bilayers which encapsulate an aqueous phase. They are normally not leaky, but can become leaky if a hole or pore occurs in the membrane, if the membrane is dissolved or degrades, or if the membrane temperature is increased to the phase transition temperature. Current methods of drug delivery via liposomes require that the liposome carrier ultimately become permeable and release the encapsulated drug at the target site. This can be accomplished, for example, in a passive manner wherein the liposome bilayer degrades over time through the action of various agents in the body. Every liposome composition will have a characteristic half-life in the circulation or at other sites in the body and, thus, by controlling the half-life of the liposome composition, the rate at which the bilayer degrades can be somewhat regulated.

In contrast to passive drug release, active drug release involves using an agent to induce a permeability change in the liposome vesicle. Liposome membranes can be constructed so that they become destabilized when the environment becomes acidic near the liposome membrane (see, e.g., Proc. Natl. Acad. Sci. USA 84:7851 (1987); Biochemistry 28:908 (1989), which are hereby incorporated by reference). When liposomes are endocytosed by a target cell, for example, they can be routed to acidic endosomes which will destabilize the liposome and result in drug release.

Alternatively, the liposome membrane can be chemically modified such that an enzyme is placed as a coating on the membrane which slowly destabilizes the liposome. Since control of drug release depends on the concentration of enzyme

initially placed in the membrane, there is no real effective way to modulate or alter drug release to achieve “on demand” drug delivery. The same problem exists for pH-sensitive liposomes in that as soon as the liposome vesicle comes into contact with a target cell, it will be engulfed and a drop in pH will lead to drug release.

5                   This liposome delivery system can also be made to accumulate at a target organ, tissue, or cell via active targeting (e.g., by incorporating an antibody or hormone on the surface of the liposomal vehicle). This can be achieved according to known methods.

10                   Different types of liposomes can be prepared according to Bangham et al., (1965); U.S. Patent No. 5,653,996 to Hsu et al., U.S. Patent No. 5,643,599 to Lee et al.; U.S. Patent No. 5,885,613 to Holland et al.; U.S. Patent No. 5,631,237 to Dzau et al.; and U.S. Patent No. 5,059,421 to Loughrey et al.

15                   An alternative approach for delivery of effector proteins involves the conjugation of the desired effector protein to a polymer that is stabilized to avoid enzymatic degradation of the conjugated effector protein. Conjugated proteins or polypeptides of this type are described in U.S. Patent No. 5,681,811 to Ekwuribe.

20                   Yet another approach for delivery of proteins or polypeptides involves preparation of chimeric proteins according to U.S. Patent No. 5,817,789 to Heartlein et al. The chimeric protein can include a ligand domain and, e.g., an effector protein of the present invention. The ligand domain is specific for receptors located on a target cell. Thus, when the chimeric protein is delivered intravenously or otherwise introduced into blood or lymph, the chimeric protein will adsorb to the targeted cell, and the targeted cell will internalize the chimeric protein, which allows the effector protein to de-stabilize the cell checkpoint control mechanism, affording its cytotoxic effects.

25                   When it is desirable to achieve heterologous expression of an effector protein of the present invention in a target cell, DNA molecules encoding the desired effector protein can be delivered into the cell. Basically, this includes providing a nucleic acid molecule encoding the effector protein and then introducing the nucleic acid molecule into the cell under conditions effective to express the effector protein in the cell. Preferably, this is achieved by inserting the nucleic acid molecule into an expression vector before it is introduced into the cell.

30

When transforming mammalian cells for heterologous expression of an effector protein, an adenovirus vector can be employed. Adenovirus gene delivery vehicles can be readily prepared and utilized given the disclosure provided in Berkner, 1988, and Rosenfeld et al., 1991. Adeno-associated viral gene delivery vehicles can be constructed and used to deliver a gene to cells. The use of adeno-associated viral gene delivery vehicles *in vitro* is described in Chatterjee et al. 1992; Walsh et al. 1992; Walsh et al., 1994; Flotte et al., 1993a; Ponnazhagan et al., 1994; Miller et al., 1994; Einerhand et al., 1995; Luo et al., 1995; and Zhou et al., 1996. *In vivo* use of these vehicles is described in Flotte et al., 1993b and Kaplitt et al., 1994. Additional types of adenovirus vectors are described in U.S. Patent No. 6,057,155 to Wickham et al.; U.S. Patent No. 6,033,908 to Bout et al.; U.S. Patent No. 6,001,557 to Wilson et al.; U.S. Patent No. 5,994,132 to Chamberlain et al.; U.S. Patent No. 5,981,225 to Kochanek et al.; U.S. Patent No. 5,885,808 to Spooner et al.; and U.S. Patent No. 5,871,727 to Curiel.

Retroviral vectors which have been modified to form infective transformation systems can also be used to deliver nucleic acid encoding a desired effector protein into a target cell. One such type of retroviral vector is disclosed in U.S. Patent No. 5,849,586 to Kriegler et al.

Regardless of the type of infective transformation system employed, it should be targeted for delivery of the nucleic acid to a specific cell type. For example, for delivery of the nucleic acid into tumor cells, a high titer of the infective transformation system can be injected directly within the tumor site so as to enhance the likelihood of tumor cell infection. The infected cells will then express the desired effector protein, e.g., HopPtoA, HopPsyA, or HopPtoA2, disrupting cellular functions and producing cytotoxic effects.

Particularly preferred is use of the effector proteins of the present invention to treat a cancerous condition (i.e., the eukaryotic cell which is affected is a cancer cell). This can be carried out by introducing a cytotoxic *Pseudomonas* protein into cancer cells of a patient under conditions effective to inhibit cancer cell division, thereby treating the cancerous condition.

By introducing, it is intended that the effector protein is administered to the patient, preferably in the form of a composition which will target delivery to the

cancer cells. Alternatively, when using DNA-based therapies, it is intended that the introducing be carried out by administering a target DNA delivery system to the patient such that the cancer cells are targeted and the effector protein is expressed therein.

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### Examples

The following Examples are intended to be illustrative and in no way are intended to limit the scope of the present invention.

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#### **Materials and Methods**

Bacterial Strains, Culture Conditions, Plasmids, and DNA Manipulation Techniques:

Three experimentally amenable strains that represent different levels of diversity in *P. syringae* were investigated: *Psy* 61, *Psy* B728a, and *Pto* DC3000.

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(i) *Psy* 61 is a weak pathogen of bean whose *hrp* gene cluster, cloned on cosmid pHIR11, contains all of the genes necessary for nonpathogenic bacteria like *Pseudomonas fluorescens* and *Escherichia coli* to elicit the HR in tobacco and to secrete in culture the HrpZ harpin, a protein with unknown function that is secreted abundantly by the Hrp system (Alfano et al., 1996). The pHIR11 *hrp* cluster has been completely sequenced (Figure 1) (Alfano and Collmer, 1997), and the *hopPsyA* gene in the hypervariable region at the left edge of the cluster was shown to encode a protein that has an Avr phenotype, travels the Hrp pathway, and elicits cell death when expressed in tobacco cells (Alfano and Collmer, 1997; Alfano et al., 1997; van Dijk et al., 1999). (ii) *Psy* B728a is in the same pathovar as strain 61 but is highly virulent and is a model for studying the role of the Hrp system in epiphytic fitness and pathogenicity (brown spot of bean) in the field (Hirano et al., 1999). (iii) *Pto* DC3000 is a well-studied pathogen of Arabidopsis and tomato (causing bacterial speck) that is highly divergent from pathovar syringae strains. Analysis of rRNA operon RFLP patterns has indicated that *Pto* and *Psy* are distantly related and could be considered separate species (Manceau and Horvais, 1997). Thus, we were able to compare two strains in the same pathovar with a strain from a highly divergent pathovar.

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Conditions for culturing *E. coli* and *P. syringae* strains have been described (van Dijk et al., 1999), as have the sources for *Psy* 61 (Preston et al., 1995), *Psy* B728a (Hirano et al., 1999), and *Pto* DC3000 (Preston et al., 1995). Cloning and DNA manipulations were done in *E. coli* DH5 $\alpha$  using pBluescript II (Stratagene, La Jolla, CA), pRK415 (Keen et al., 1988), and cosmid pCPP47 (Bauer and Collmer, 1997), according to standard procedures (Ausubel et al., 1994). Cosmid libraries of *Pto* DC3000 and *Psy* B728a genomic DNA were previously constructed (Charkowski et al., 1998). Oligonucleotide synthesis and DNA sequencing were performed at the Cornell Biotechnology Center. The nucleotide sequence of the *Pto* DC3000 *hrp/hrc* cluster was determined using subclones of pCPP2473, a cosmid selected from a genomic cosmid library based on hybridization with the *hrpK* gene of *Psy* 61. The nucleotide sequence of the *Psy* B728a *hrp/hrc* cluster was determined using subclones of pCPP2346 and pCPP3017. These cosmids were selected from a genomic library based on hybridization with the *hrpC* operon of 61. The left side of the *Psy* 61 EEL region was cloned by PCR into pBSKSII+ *Xho*I and *Eco*RI sites using the following primers:

SEQ. ID. NO. 71, which primes within *queA* and contains an *Xho*I site:

atgactcgag gcggtggattc aggcaaat 28

SEQ. ID. NO. 72, which primes within *hopPsyA* and contains an *Eco*RI site:

atgagaattc tgccgceget ttctcggt 28

Pfu polymerase was used for all PCR experiments. DNA sequence data were managed and analyzed with the DNASTar Program (Madison, WI), and databases were searched with the BLASTX, BLASTP, and BLASTN programs (Altschul et al., 1997).

#### Mutant Construction and Analysis:

Large deletions in the *Pto* DC3000 Hrp Pai were constructed by subcloning border fragments into restriction sites on either side of an  $\Omega$ Sp<sup>R</sup> cassette in pRK415, electroporating the recombinant plasmids into DC3000, and then selecting and screening for marker exchange mutants as described (Alfano et al., 1996). The

following left and right side (Figures 2 and 3) deletion border fragments were used (with residual gene fragments indicated): for CUCPB5110 left *tgt-gueA*-tRNA<sup>Leu</sup> - ORF4' (27 bp of ORF4) and right ORF1'-*hrpK* (396 bp of ORF1); and for CUCPB5115 left *hrpS'*-*avrE'* (2569 bp of *avrE*) and right ORF6 (156 bp upstream of ORF6 start codon). The later fragment was PCR-amplified using the following primers:

SEQ. ID. NO. 73, which primes in the ORF5-ORF6 intergenic region and contains an *Xba*I site:

10 cgctctagac caaggactgc 20

SEQ. ID. NO. 74, which primes in ORF6 and contains a *Hind*III site:

ccagaagctt ctgtttttga gtc 23

15 Mutant constructions were confirmed by Southern hybridizations using previously described conditions (Charkowski et al., 1998). The ability of mutants to secrete AvrPto was determined with anti-AvrPto antibodies and immunoblot analysis of cell fractions as previously described (van Dijk et al., 1999). Mutant CUCPB5115 was complemented with pCPP3016, which carries ORF2 through ORF10 in cosmid  
20 pCPP47, and was introduced from *E. coli* DH5 $\alpha$  by triparental mating using helper strain *E. coli* DH5 $\alpha$ (pRK600), as described (Charkowski et al., 1998).

#### T7 Expression Analysis:

Protein products of the *Pto* DC3000 EEL were analyzed by T7  
25 polymerase-dependent expression using vector pET21 and *E. coli* BL21(DE3) as previously described (Huang et al., 1995). The following primer sets were used to PCR each ORF from pCPP3091, which carries in pBSKSII+ a *Bam*HI fragment containing *tgt* to *hrcV*:

30 ORF1, SEQ. ID. Nos. 75 and 76, respectively:

agtaggatcc tgaaatgtag gggcccg 28

agtaaagctt atgatgctgt ttccagta 28

ORF2, SEQ. ID. Nos. 77 and 78, respectively:

35 agtaggatcc tctcgaagga atggagca 28

agtaaagctt cgtgaagatg catttcgc 28

ORF3, SEQ. ID. Nos. 79 and 80, respectively:

agtaggatcc tagtcactga tcgaacgt 28

5 agtactcgag ccacgaaata acacggta 28

ORF4, SEQ. ID. Nos. 81 and 82, respectively:

agtaggatcc caggactgcc ttccagcg 28

agtactcgag cagagcggcg tccgtggc 28

10

*tnpA*, SEQ. ID. Nos. 83 and 84, respectively:

agtaggatcc agaattgttg aagaaatc 28

agtaaagctt tgcgctgtta actcatcg 28

15 Plant Bioassays:

Tobacco (*Nicotiana tabacum* L. cv. Xanthi) and tomato

(*Lycopersicon esculentum* Mill. cvs. Moneymaker and Rio Grande) were grown

under greenhouse conditions and then maintained at 25°C with daylight and

supplemental halide illumination for HR and virulence assays. Bacteria were grown

20 overnight on King's medium B agar supplemented with appropriate antibiotics,

suspended in 5 mM MES pH 5.6, and then infiltrated with a needleless syringe into

the leaves of test plants at  $10^8$  cfu/ml for HR assays and  $10^4$  cfu/ml for pathogenicity

assays (Charkowski et al., 1998). All assays were repeated at least four times on

leaves from different plants. Bacterial growth in tomato leaves was assayed by

25 excising disks from infiltrated areas with a cork borer, comminuting the tissue in

0.5 ml of 5 mM MES, pH 5.6, with a Kontes Pellet Pestle (Fisher Scientific,

Pittsburgh, PA), and then dilution plating the homogenate on King's medium B agar

with 50 µg/ml rifampicin and 2 µg/ml cycloheximide to determine bacterial

populations. The mean and SD from three leaf samples were determined for each

30 time point. The relative growth in planta of DC3000 and CUCPB5110 was similarly

assayed in 4 independent experiments and the relative growth of DC3000,

CUCPB5115, and CUCPB5115(pCPP3016) in 3 independent experiments. Although

the final population levels achieved by DC3000 varied between experiments, the

populations levels of the mutants relative to the wild type were the same as in the representative experiments presented below.

**Example 1 - Comparison of *hrp/hrc* Gene Clusters of *Psy* 61, *Psy* B728a, and *Pto* DC3000**

To determine if the *hrp/hrc* clusters from *Psy* B728a and *Pto* DC3000 were organized similarly to the previously characterized *hrp/hrc* cluster of *Psy* 61, two cosmids carrying *hrp/hrc* inserts were partially characterized. pCPP2346 carries the entire *hrp/hrc* cluster of B728a, and pCPP2473 carries the left half of the *hrp/hrc* cluster of DC3000. The right half of the DC3000 *hrp/hrc* cluster had been characterized previously (Preston et al., 1995). Sequencing the ends of several subclones derived from these cosmids provided fingerprints of the B728a and DC3000 *hrp/hrc* clusters, which indicated that both are arranged like that of strain 61 (Fig. 1). However, B728a contains between *hrcU* and *hrpV* a 3.6-kb insert with homologs of bacteriophage lambda genes Ea59 (23% amino-acid identity;  $E = 2e-7$ ) and Ea31 (30% amino-acid identity;  $E = 6e-8$ ) (Hendrix et al., 1983), and the B728a *hrcU* ORF has 36 additional codons. A possible insertion of this size in several *Psy* strains that are highly virulent on bean was suggested by a previous RFLP analysis (Legard et al., 1993). Cosmid pCPP2346, which contains the B728a *hrp/hrc* region and flanking sequences (4 kb on the left and 13 kb on the right), enabled *P. fluorescens* to secrete the B728a HrpZ harpin in culture and to elicit the HR in tobacco leaves, however, confluent necrosis developed more slowly than with *P. fluorescens*(pHIR11) (data not shown). To further test the relatedness of the *Psy* 61 and B728a *hrp/hrc* gene clusters using an internal reference, the B728a *hrpA* gene was sequenced. Of the *hrp/hrc* genes that have been sequenced in *Psy* and *Pto*, *hrpA*, which encodes the major subunit of the Hrp pilus (Roine et al., 1997), is the least conserved (28% amino-acid identity) (Preston et al., 1995). However, the *hrpA* genes of strains 61 and B728a were 100% identical, which further supports the close relationship of these strains and their Hrp systems.

**Example 2 - Identification of an Exchangeable Effector Locus (EEL) in the Hrp Pai between *hrpK* and tRNA<sup>Leu</sup>**

Sequence analysis of the left side of the *Psy* 61, *Psy* B728a, and *Pto* DC3000 Hrp Pairs revealed that the high percentage identity in *hrpK* sequences in these strains abruptly terminates three nucleotides after the *hrpK* stop codon and then is restored near tRNA<sup>Leu</sup>, *queA*, and *tgt* sequences after 2.5 kb (*Psy* 61), 7.3 kb (*Psy* B728a), or 5.9 kb (*Pto* DC3000) of dissimilar, intervening DNA (Figure 2). The difference between *Psy* strains 61 and B728a in this region was particularly surprising. This region of the *P. syringae* Hrp Pai was given the EEL designation because it contained completely different effector protein genes (Table 1 below), which appear to be exchanged at this locus at a high frequency. In this regard, it is noteworthy that (i) ORF2 in the B728a EEL is a homolog of *avrPphE*, which is in a different location, immediately downstream of *hrpK* (*hrpY*), in *Pph* 1302A (Mansfield et al., 1994), (ii) *hopPsyA* (*hrmA*) is present in only a few *Psy* strains (Heu and Hutcheson, 1993; Alfano et al., 1997), (iii) and ORF5 in the B728a EEL predicts a protein that is similar to *Xanthomonas* AvrBsT and possesses multiple motifs characteristic of the AvrRxv family (Ciesiolka et al., 1999). G+C content different from the genomic average is a hallmark of horizontally transferred genes, and the G + C contents of the ORFs in the three EELs are considerably lower than the average of 59-61% for *P. syringae* (Palleroni et al., 1984) (Table 1 below). They are also lower than *hrpK* (60%) and *queA* (63-64%). The ORFs in the *Pto* DC3000 EEL predict no products with similarity to known effector proteins, however T7 polymerase-dependent expression revealed products in the size range predicted for ORF1, ORF3, and ORF4. Furthermore, the ORF1 protein is secreted in a *hrp*-dependent manner by *E. coli*(pCPP2156), which expresses an *Erwinia chrysanthemi* Hrp system that secretes *P. syringae* Avr proteins (Ham et al., 1998). Several ORFs in these EELs are preceded by Hrp boxes indicative of HrpL-activated promoters (Figure 1) (Xiao and Hutcheson, 1994), and the lack of intervening Rho-independent terminator sequences or promoters suggests that ORF1 in DC3000 and ORF1 and ORF2 in B728a are expressed from HrpL-activated promoters upstream of the respective *hrpK* genes.

The EELs of these three strains also contain sequences homologous to insertion sequences, transposases, phage integrase genes, and plasmids (Figure 2 and Table 1 below). The *Psy* B728a ORF5 and ORF6 operon is bordered on the left side

by sequences similar to those in a *Pph* plasmid that carries several *avr* genes (Jackson et al., 1999) and by a sequence homologous to insertion elements that are typically found on plasmids, suggesting plasmid integration via an IS element in this region (Szabo and Mills, 1984). *Psy* B728a ORF3 and ORF4 show similarity to sequences implicated in the horizontal acquisition of the LEE *Pai* by pathogenic *E. coli* strains (Perna et al., 1998). These *Psy* B728a ORFs are not preceded by Hrp boxes and are unlikely to encode effector proteins.

Table 1: ORFs and fragments of genetic elements in the EELs of *Pto* DC3000, *Psy* B728a, and *Psy* 61 and similarities with known *avr* genes and mobile genetic elements.

ORF or sequence	% G+C	Size	BLAST <i>E</i> value with representative similar sequence(s) in database, or relevant feature
<i>Pto</i> DC3000 <sup>a</sup>			
ORF1	55	466 aa	Hrp-secreted (Alfano, unpublished)
TnpA'	55	279 aa	1e-125 <i>P. stutzeri</i> TnpA1 (Bosch et al., 1999)
ORF2	51	241 aa	None
ORF3	53	138 aa	None
ORF4	47	136 aa	None
<i>Psy</i> B728a			
ORF1	51	323 aa	9e-40 <i>Pph</i> AvrPphC (Yucel et al., 1994)
ORF2	58	382 aa	1e-154 <i>Pph</i> AvrPphE (Mansfield et al., 1994)
ORF3	55	507 aa	2e-63 <i>E. coli</i> L0015 (Perna et al., 1998)
ORF4	55	118 aa	9e-9 <i>E. coli</i> L0014 (Perna et al., 1998)
ORF5	49	411 aa	1e-4 <i>Xcv</i> AvrBsT (Ciesiolka et al., 1999)
ORF6	52	120 aa	None
B plasmid	46	96 nt	1e-25 <i>Pph</i> pAV511 (Jackson et al., 1999)
IntA'	59	49 aa	3e-5 <i>E. coli</i> CP4-like integrase (Perna et al., 1998)
<i>Psy</i> 61			
HopPsyA	53	375 aa	Hrp-secreted Avr (Alfano et al., 1997; van Dijk et al., 1999)
ShcA	57	112 aa	6e-4 Y0008 (Perry et al., 1998)

<sup>a</sup> Pathovar abbreviations correspond to the recommendations of Vivian and Mansfield (1993) for uniform *avr* nomenclature.

The left border of the EELs contains sequences similar to many tRNA<sup>Leu</sup> genes and to *E. coli queA* and *tgt* queuosine biosynthesis genes (ca. 70% amino-acid identity in predicted products). The EEL sequences terminate at the 3' end of the *P. syringae* tRNA sequences, as is typical for *Pais* (Hou, 1999). Virtually identical *tgt-queA*-tRNA<sup>Leu</sup> sequences are found in the genome of *P. aeruginosa* PAO1 (www.pseudomonas.com), which is also in the fluorescent pseudomonad group. But PAO1 is not a plant pathogen, and this tRNA<sup>Leu</sup> in *P. aeruginosa* is not

linked to any type III secretion system genes or other genes in the Hrp Pai (Figure 2). Thus, this is the apparent point of insertion of the Hrp Pai in the ancestral *Pseudomonas* genome.

5    **Example 3 - Identification of a Conserved Effector locus (CEL) Located on the Right Side of the Hrp Pai in *Psy* B728a and *Pto* DC3000**

Previous studies of the region to the right of *hrpR* in DC3000 had revealed the existence of the *avrE* locus, which is comprised of two transcriptional units (Lorang and Keen, 1995), the 5' sequences for the first 4 transcriptional units  
10    beyond *hrpR* (Lorang and Keen, 1995), and the identity of the fourth transcriptional unit as the *hrpW* gene encoding a second harpin (Charkowski et al., 1998). The DNA sequence of the first 14 ORFs to the right of *hrpR* in *Pto* DC3000 was completed in this investigation and the corresponding region in *Psy* B728a was partially sequenced (Figure 3). Like the EEL, this region contains putative effector genes, e.g., *avrE*  
15    (Lorang and Keen, 1995). Unlike the EEL, the ORFs in this region have an average G + C content of 58.0% , which is close to that of the *hrp/hrc* genes, the region contains no sequences similar to known mobile genetic elements, and it appears conserved between *Psy* and *Pto* (Figure 3). Comparison of the regions sequenced in B728a and DC3000 revealed that the first 7 ORFs are arranged identically and have  
20    an average DNA sequence identity of 78%. Hence, this region was given the CEL designation.

The precise border of the CEL remains undefined, and no sequences that were repeated in the EEL border of the Hrp Pai were found. ORF7 and ORF8 are likely to be part of the CEL, based on the presence of an upstream Hrp box (Figure 3).  
25    However, the region beyond ORF10 probably is not in the CEL because the product of the next ORF shows homology to a family of bacterial GstA proteins (e.g., 28% identity with *E. coli* GstA over 204 amino acids;  $E = 1e-8$ )(Blattner et al., 1997), and glutathione-S-transferase activity is common in nonpathogenic fluorescent pseudomonads (Zablotowicz et al., 1995). The presence of a *galP* homolog (38%  
30    identity over 256 amino acids, based on incomplete sequence, to *E. coli* GalP;  $E = 2e-42$ ) (Blattner et al., 1997) in this region further suggests that it is beyond the CEL.

Several other features of this region in B728a and DC3000 are noteworthy. (i) Both strains have a 1-kb intergenic region between *hrpR* and ORF1

that is distinguished by low sequence identity (44%) but which contains three inverted repeats that could form stem loop structures affecting expression of the *hrpRS* operon. (ii) ORF1 is most similar to *E. coli* murein lytic transglycosylase MltD (38% identity over 324 amino acids;  $E = 4e-56$ ). (iii) ORF2 is 42% identical over 130 amino acids with *E. amylovora* DspF ( $E = 9e-24$ ), a candidate chaperone (Bogdanove et al., 1998a; Gaudriault et al., 1997). (iv) The ORF5 protein is secreted in a *hrp*-dependent manner by *E. coli*(pCPP2156), but mutation with an  $\Omega\text{Sp}^r$  cassette has little effect on either HR elicitation in tobacco or pathogenicity in tomato (Charkowski, unpublished). (v) Finally, six operons in this region are preceded by Hrp boxes (Lorang and Keen, 1995) (Figure 3), which is characteristic of known *avr* genes in *P. syringae* (Alfano et al., 1996). Thus, the CEL carries multiple candidate effectors.

#### **Example 4 - Investigation of EEL and CEL Roles in Pathogenicity**

A mutation was constructed in DC3000 that replaced all of the ORFs between *hrpK* and tRNA<sup>Leu</sup> (EEL) with an  $\Omega\text{Sp}^r$  cassette (Figure 2). This *Pto* mutant, CUCPB5110, was tested for its ability to elicit the HR in tobacco and to cause disease in tomato. The mutant retained the ability to elicit the HR and to produce disease symptoms, but it failed to reach population levels as high as the parental strain in tomato (Figure 4A).

A mutation was constructed in DC3000 that replaced *avrE* through ORF5 (CEL) with an  $\Omega\text{Sp}^r$  cassette. This deleted all of the CEL ORFs that were both partially characterized and likely to encode effectors. This *Pto* mutant, CUCPB5115, still elicited the HR in tobacco, but tissue collapse was delayed ca. 5 h (Figure 4C). The mutant no longer elicited disease symptoms in tomato when infiltrated at a concentration of  $10^4$  cfu/ml, and growth *in planta* was strongly reduced (Figure 4B). However, the mutant elicited an HR dependent on the tomato *Pto R* gene that was indistinguishable from the wild-type in tests involving PtoS (susceptible) and PtoR (resistant) Rio Grande tomato lines. Plasmid pCPP3016, which carries ORF2 through ORF10, fully restored the ability of CUCPB5115 to cause disease symptoms and partially restored the ability of the mutant to multiply in tomato leaves (Figures 4B and 4E). Deletion of the *hrp/hrc* cluster abolishes HR and pathogenicity phenotypes in *Pto* DC3000 (Collmer et al., 2000). To confirm that the large deletions in *Pto*

mutants CUCPB5110 and CUCPB5115 did not disrupt Hrp secretion functions, we compared the ability of these mutants, the DC3000 *hrp/hrc* deletion mutant, and wild-type DC3000 to make and secrete AvrPto in culture while retaining a cytoplasmic marker comprised of  $\beta$ -lactamase lacking its signal peptide. AvrPto provided an ideal  
5 subject for this test because it is a well-studied effector protein that is secreted in culture and injected into host cells *in planta* (Alfano and Collmer, 1997; van Dijk et al., 1999). Only the *hrp/hrc* deletion cluster mutant was impaired in AvrPto production and secretion (Figure 5).

Based on the above studies, the *P. syringae* *hrp/hrc* genes are part of a  
10 Hrp Pai that has three distinct loci: an EEL, the *hrp/hrc* gene cluster, and a CEL. The EEL harbors exchangeable effector genes and makes only a quantitative contribution to parasitic fitness in host plants. The *hrp/hrc* locus encodes the Hrp secretion system and is required for effector protein delivery, parasitism, and pathogenicity. The CEL makes no discernible contribution to Hrp secretion functions but contributes strongly  
15 to parasitic fitness and is required for *Pto* pathogenicity in tomato. The Hrp Pai of *P. syringae* has several properties of Pais possessed by animal pathogens (Hacker et al., 1997), including the presence of many virulence-associated genes (several with relatively low G+C content) in a large (ca. 50-kb) chromosomal region linked to a tRNA locus and absent from the corresponding locus in a closely related species. In  
20 addition, the EEL portion of the Hrp Pai is unstable and contains many sequences related to mobile genetic elements.

The EEL is a novel feature of known Pais, which is likely involved in fine-tuning the parasitic fitness of *P. syringae* strains with various plant hosts. By comparing closely- and distantly-related strains of *P. syringae*, we were able to  
25 establish the high instability of this locus and the contrasting high conservation of its border sequences. No single mechanism can explain the high instability, as we found fragments related to phages, insertion sequences, and plasmids in the *Psy* and *Pto* EELs, and insertion sequences were recently reported in the corresponding region of three other *P. syringae* strains (Inoue and Takikawa, 1999). The mechanism or  
30 significance of the localization of the EELs between tRNA<sup>Leu</sup> and *hrpK* sequences in the Hrp Pais also is unclear. *Pto* DC3000 carries at least one other effector gene, *avrPto*, that is located elsewhere in the genome (Ronald et al., 1992), many

*P. syringae* *avr* genes are located on plasmids (Leach and White, 1996), and the EEL ORFs represent a mix of widespread, (e.g., *avrRxv* family) and seemingly rare (e.g., *hopPsyA*), effector genes. The G + C content of the EEL ORFs is significantly lower than that of the rest of the Hrp Pai and the *P. syringae* genome. Although certain

5 genes in the non-EEL portions of the Hrp Pai, such as *hrpA*, are highly divergent, they have a high G + C content, and there is no evidence that they have been horizontally transferred separately from the rest of the Hrp Pai. The relatively low G + C content of the ORFs in the EELs (and of other *P. syringae* *avr* genes) suggests that these

10 *P. syringae* (Kim et al., 1998). Indeed, the *avrRxv* family of genes is found in a wide range of plant and animal pathogens (Ciesiolka et al., 1999). The weak effect on parasitic fitness of deleting the *Pto* DC3000 EEL, or of mutating *hopPsyA* (*hrmA*) in *Psy* 61 (Huang et al., 1991), is typical of mutations in individual *avr* genes and presumably results from redundancy in the effector protein system (Leach and White,

15 1996).

The functions of *hrpK* and of the CEL ORF1 are unclear but warrant discussion. These two ORFs reside just outside the *hrpL* and *hrpR* delimited cluster of operons containing both *hrp* and *hrc* genes and thereby spatially separate the three regions of the Hrp Pai (Figures 1-3). *hrpK* mutants have a variable Hrp phenotype

20 (Mansfield et al., 1994; Bozso et al., 1999), and a *Psy* B728a *hrpK* mutant still secretes HrpZ (Alfano, unpublished), which suggests that HrpK may be an effector protein. Nevertheless, the HrpK proteins of *Psy* 61 and *Pto* DC3000 are 79% identical and therefore are more conserved than many Hrp secretion system components. It is also noteworthy that *hrpK* appears to be in an operon with other

25 effector genes in *Psy* B728a and *Pto* DC3000. In contrast, the CEL ORF1 may contribute (weakly or redundantly) to Hrp secretion functions by promoting penetration of the system through the bacterial peptidoglycan layer. The ORF1 product has extensive homology with *E. coli* MltD and shares a lysozyme-like domain with the product of *ipgF* (Mushegian et al., 1996), a *Shigella flexneri* gene that is also

30 located between loci encoding a type III secretion system and effector proteins (Allaoui et al., 1993). Mutations in these genes in *Pto* and *S. flexneri* have no

obvious phenotype (Lorang and Keen, 1995; Allaoui et al., 1993), as is typical for genes encoding peptidoglycan hydrolases (Dijkstra and Keck, 1996).

The loss of pathogenicity in *Pto* mutant CUCPB5115, with an *avrE*-ORF5 deletion in the CEL, was surprising because pathogenicity is retained in  
5 DC3000 mutants in which the corresponding operons are individually disrupted (Lorang and Keen, 1995; Charkowski et al., 1998). In assessing the possible function of this region and the conservation of its constituent genes, it should be noted that *avrE* is unlike other *avr* genes found in *Pto* in that it confers avirulence to *P. syringae* pv *glycinea* on all tested soybean cultivars and it has a homolog (*dspE*) in  
10 *E. amylovora* that is required for pathogenicity (Lorang and Keen, 1995; Bogdanove et al., 1998b). Although the CEL is required for pathogenicity, it is not essential for type III effector protein secretion because the mutant still secretes AvrPto. It also appears to play no essential role in type III translocation of effector proteins into plant cells because the mutant still elicits the HR in nonhost tobacco and in a PtoR-  
15 resistance tomato line, and pHIR11, which lacks this region, appears capable of translocating several Avr proteins (Gopalan et al., 1996; Pirhonen et al., 1996). The conservation of this region in the divergent pathovars *Psy* and *Pto*, and its importance in disease, suggests that the products of the CEL may be redundantly involved in a common, essential aspect of pathogenesis.

20 The similar G + C content and codon usage of the *hrp/hrc* genes, the genes in the CEL, and total *P. syringae* genomic DNA suggests that the Hrp Pai was acquired early in the evolution of *P. syringae*. Although, the EEL region may have similarly developed early in the radiation of *P. syringae* into its many pathovars, races, and strains, the apparent instability that is discussed above suggests ongoing  
25 rapid evolution at this locus. Indeed, many *P. syringae* *avr* genes are associated with mobile genetic elements, regardless of their location (Kim et al., 1998). Thus, it appears that Hrp-mediated pathogenicity in *P. syringae* is collectively dependent on a set of genes that are universal among divergent pathovars and on another set that varies among strains even in the same pathovar. The latter are presumably acquired  
30 and lost in response to opposing selection pressures to promote parasitism while evading host *R*-gene surveillance systems.

**Example 5 - Role of ShcA as a Type III Chaperone for the HopPsyA Effector**

The ORF upstream of *hopPsyA*, tentatively named *shcA*, encodes a protein product of the predicted molecular mass. The ORF upstream of the *hopPsyA* gene in *P. s. syringae* 61 (originally designated ORF1) shares sequence identity with  
5 *exsC* and ORF7, which are genes adjacent to type III effector genes in *P. aeruginosa* and *Yersinia pestis*, respectively (Frank and Iglewski, 1991; Perry et al., 1998).

Although neither of these ORFs have been shown experimentally to encode chaperones, they have been noted to share properties that type III chaperones often possess (Cornellis et al., 1998). One of these properties is the location of the  
10 chaperone gene itself (Figures 1 and 6). Chaperone genes are often adjacent to a gene that encodes the effector protein with which the chaperone interacts. Furthermore, *shcA* also shares other common characteristics of type III chaperones: its protein product is relatively small (about 14 kDa), it has an acidic pI, and it has a C-terminal region that is predicted to be an amphipathic  $\alpha$ -helix. To begin assessing the function  
15 of *shcA*, it was first determined whether *shcA* encodes a protein product. A construct was prepared using PCR that fused *shcA* in-frame to a sequence encoding the FLAG epitope. This construct, pLV26, contains the nucleotide sequence upstream of *shcA*, including a putative ribosome binding site (RBS). DH5 $\alpha$ F'IQ(pLV26) cultures were grown in rich media and induced at the appropriate density with IPTG. Whole cell  
20 lysates were separated by SDS-PAGE and analyzed with immunoblots using anti-FLAG antibodies. By comparing the ShcA-FLAG encoded by pLV26 to a construct that made ShcA-FLAG from a vector RBS, it was concluded that the native RBS upstream of *shcA* was competent for translation (Figure 7). Thus, the *shcA* ORF is a legitimate gene that encodes a protein product.

25 To test the effects of *shcA* on bacterial-plant interactions, an *shcA* mutation was constructed in the minimalist *hrp/hrc* cluster carried on cosmid pHIR11. There are distinct advantages to having the *shcA* mutation marker-exchanged into pHIR11. The main one is that the HR assay can be used as a screen to determine if HopPsyA is being translocated into plant cells because the pHIR11-dependent HR  
30 requires the delivery of HopPsyA into plant cells (Alfano et al., 1996; Alfano et al., 1997). With the chromosomal *shcA* mutant, other Hop proteins would probably be delivered to the interior of plant cells. Some of these proteins would be recognized by

the *R* gene-based plant surveillance system and initiate an HR masking any defect in HopPsyA delivery. *E. coli* MC4100 carrying pLV10, a pHIR11 derivative, which contains a nonpolar *nptII* cartridge within *shcA*, was unable to elicit an HR on tobacco (Figure 8). This indicates that *shcA* is required for the translocation of HopPsyA into  
5 plant cells. To determine if HopPsyA was secreted in culture, cultures of the nonpathogen *P. fluorescens* 55 were grown. This bacterium carried either pHIR11, pCPP2089 (a pHIR11 derivative defective in type III secretion), or pLV10. The representative results can be seen in Figure 8. *shcA* was required for the in-culture type III secretion of the HopPsyA effector protein, but not for HrpZ secretion, another  
10 protein secreted by the pHIR11 encoded Hrp system. These results indicate that the defect in type III secretion is specific to HopPsyA and are consistent with *shcA* encoding a chaperone for HopPsyA. It was after these results that the ORF upstream of the *hopPsyA* gene was named *shcA* for specific hop chaperone for HopPsyA, a naming system consistent with the naming system researchers have employed for  
15 chaperones in the archetypal *Yersinia* type III system.

#### **Example 6 - Cytotoxic Effects of *hopPsyA* Expressed in Plants**

Transient expression of *hopPsyA* DNA *in planta* induces cell death in *Nicotiana tabacum*, but not in *N. benthamiana*, bean, or in *Arabidopsis*. To determine  
20 whether HopPsyA induced cell death on tobacco leaves as it did when produced in tobacco suspension cells, a transformation system that delivers the *hopPsyA* gene on T-DNA of *Agrobacterium tumefaciens* was used (Rossi et al., 1993; van den Ackerveken et al., 1996). This delivery system works better than biolistics for transiently transforming whole plant leaves. For these experiments, vector pTA7002,  
25 kindly provided by Nam-Hai Chua and his colleagues at Rockefeller University, was used. The unique property of this vector is that it contains an inducible expression system that uses the regulatory mechanism of the glucocorticoid receptor (Picard et al., 1988; Aoyama and Chua, 1997; McNellis et al., 1998). pTA7002 encodes a chimeric transcription factor consisting of the DNA-binding domain of GAL4, the  
30 transactivating domain of the herpes viral protein VP16, and the receptor domain of the rat glucocorticoid receptor. Also contained on this vector is a promoter containing GAL4 upstream activating sequences (UAS) upstream of a multiple cloning site.

Thus, any gene cloned downstream of the promoter containing the GAL4-UAS is induced by glucocorticoids, of which a synthetic glucocorticoid, dexamethasone (DEX), is available commercially. *hopPsyA* was PCR-cloned downstream of the GAL4-UAS. Plant leaves from several different test plants were infiltrated with *Agrobacterium* carrying pTA7002::*hopPsyA* and after 48 hours these plants were sprayed with DEX. Only *N. tabacum* elicited an HR in response to the DEX-induced transient expression of *hopPsyA* (Figure 13A). In contrast, *N. benthamiana* produced no obvious response after DEX induction (Figure 13B). Moreover, transient expression of *hopPsyA* in bean plants (*Phaseolus vulgaris* L. 'Eagle')(data not shown) and *Arabidopsis thaliana* ecotype Col-1 (Figure 13) did not result in a HR. These results suggest that bean cv. Eagle, *Arabidopsis* Col-1, and *N. benthamiana* lack a resistance protein that can recognize HopPsyA. The lack of an apparent defense response for HopPsyA transiently expressed in bean was predicted, because HopPsyA is normally produced in *P. s. syringae* 61, a pathogen of bean. But, it was somewhat unknown how transient expression of HopPsyA would effect *Arabidopsis*. However, since *P. s. tomato* DC3000, a pathogen of *Arabidopsis*, appears to have a *hopPsyA* homolog based on DNA gel blots using *hopPsyA* as a probe, it was expected that HopPsyA would not to be recognized by an R protein in *Arabidopsis* (i.e., no HR produced) (Alfano et al., 1997). Thus, these plants (bean, *Arabidopsis*, and *N. benthamiana*) should represent ideal plants to explore the bacterial-intended role of HopPsyA in plant pathogenicity.

*P.s. pv. syringae* 61 secretes HopPsyA in culture via the Hrp (type III) protein secretion system. Because the *P. syringae* Avr proteins AvrB and AvrPto were found to be secreted by the type III secretion system encoded by the functional *E. chrysanthemi hrp* cluster carried on cosmid pCPP2156 expressed in *E. coli* (Ham et al., 1998), detection of HopPsyA secretion in culture directly via the native Hrp system carried in *P. s. syringae* 61 was tested. *P. s. syringae* 61 cultures grown in *hrp*-derepressing fructose minimal medium at 22°C were separated into cell-bound and supernatant fractions by centrifugation. Proteins present in the supernatant fractions were concentrated by TCA precipitation, and the cell-bound and supernatant samples were resolved with SDS-PAGE and analyzed with immunoblots using anti-HopPsyA antibodies. A HopPsyA signal was detected in supernatant fractions from

wild type *P. s. syringae* 61 (Figure 14). Importantly, HopPsyA was not detected in supernatant fractions from *P. s. syringae* 61-2089, which is defective in Hrp secretion, indicating that the HopPsyA signal in the supernatant was due specifically to type III protein secretion (Figure 14). As a second control, both strains contained pCPP2318, which encodes the mature  $\beta$ -lactamase lacking its N-terminal signal peptide, and provides a marker for cell lysis.  $\beta$ -lactamase was detected only in the cell-bound fractions of these samples, clearly showing that cell lysis did not occur at a significant level (Figure 14). The fact that HopPsyA is secreted via the type III secretion system in culture and that the avirulence activity of HopPsyA occurs only when it is expressed in plant cells strongly support that HopPsyA is delivered into plant cells via the type III pathway.

HopPsyA contributes in a detectable, albeit minor, way to growth of *P. s. syringae* 61 in bean. The effect of a HopPsyA mutation on the multiplication of *P. s. syringae* 61 in bean tissue has been reported (Huang et al., 1991). These data essentially indicate that HopPsyA contributes little to the ability of *P. s. syringae* 61 to multiply in bean. The *P. s. syringae* 61 *hopPsyA* mutant does not grow as well in bean leaves as the wild-type strain (Figure 15). This was unexpected, because these results are in direct conflict with previously reported data. One rationale for the discrepancy is that the previous reports focused primarily on the major phenotype that a *hrp* mutant exhibits on *in planta* growth and predated the discovery that HopPsyA was a type III-secreted protein. Thus, it is quite possible that the earlier experiments missed the more subtle effect that HopPsyA appears to have on the multiplication of *P. s. syringae* 61 in bean tissue (Huang et al., 1991). The data presented here supports that HopPsyA contributes to the pathogenicity of *P. s. syringae* and are consistent with the hypothesis that the majority of Hops from *P. syringae* contribute subtly to pathogenicity. The lack of strong pathogenicity phenotypes for mutants defective in different *avr* and *hop* genes may be due to possible *avr/hop* gene redundancy or a decreased dependence on any one Hop protein through coevolution with the plant. Indeed, the type III-delivered proteins of plant pathogens that are delivered into plant cells may not be virulence proteins per se, but rather they may suppress responses of the plant that are important for pathogenicity to proceed (Jakobek et al., 1993). These

responses may be defense responses or other more general processes that maintain the status quo within the plant (e.g., the cell cycle).

### **Example 7 - Molecular Interactions of HopPsyA**

5 HopPsyA interacts with the *Arabidopsis* Mad2 protein in the yeast 2-hybrid system. To determine a pathogenic target for HopPsyA, the yeast 2-hybrid system was used with cDNA libraries made from *Arabidopsis* (Fields and Song, 1989; Finley and Brent, 1994). In the yeast 2-hybrid system, a fusion between the protein of interest (the “bait”) and the LexA DNA-binding domain was transformed into a yeast  
10 tester strain. A cDNA expression library was constructed in a vector that creates fusions to a transcriptional activator domain. This library was transformed into the tester strain en masse, and clones encoding partners for the “bait” are selected via their ability to bring the transcriptional activator domain into proximity with the DNA binding domain, thus initiating transcription of the *LEU2* selectable marker gene. A  
15 second round screening of candidates, that activate the *LEU2* marker, relies on their ability to also activate a *lacZ* reporter gene. Bait constructs were initially made with *hopPsyA* in the yeast vector pEG202 that corresponded to a full-length HopPsyA-LexA fusion, the carboxy-terminal half of HopPsyA fused to LexA, and the amino-terminal half of HopPsyA fused to LexA, and named these constructs pLV23, pLV24, and pLV25, respectively. However, pLV23 was lethal to yeast and pLV25 activated  
20 the *lacZ* reporter gene in relatively high amounts on its own (i.e., without the activation domain present). Thus, both pLV23 and pLV25 were not used to screen for protein interactors via the yeast 2-hybrid system. pLV24, which contains the 3’ portion of *hopPsyA* fused to *lexA*, proved to be an appropriate construct to use for bait  
25 in the yeast 2-hybrid system, because it did not autoactivate the *lacZ* reporter gene and, based on the *lacZ* repression assay using pJK101, the ‘HopPsyA-LexA fusion produced by pLV24 appeared to localize to the nucleus. In addition, it was confirmed that pLV24 made a protein of the appropriate size that corresponds to HopPsyA by performing immunoblots with anti-HopPsyA antibodies on yeast cultures carrying  
30 this vector.

Initial screens with pLV24 and *Arabidopsis* cDNA libraries in the yeast 2-hybrid vector pJG4-5. From three independent screens, several hundred

putative interactors with HopPsyA were identified, each activating the two reporter systems to varying degrees. When these putative positive yeast strains were rescreened and criteria were limited to interactors that strongly induced both the *lacZ* reporter and *LEU2* gene in the presence of galactose, about 50 yeast strains were identified that appeared to contain pJG4-5 derivatives that encoded proteins that could interact with the C-terminal half of HopPsyA. DNA gel blots using PCR-amplified inserts from selected pJG4-5 derivatives as probes allowed each of these putative positives to be grouped. Approximately 50% of the pJG4-5 derivatives that encoded strong HopPsyA interactors belonged to the same group. A pJG4-5 derivative containing this insert, pLV116 was sequenced. The predicted amino acid sequence of the insert contained within pLV116 shared high amino acid identity to Mad2 homologs (for mitotic arrest deficient) found in yeast, humans, frogs, and corn. Moreover, based on amino acid comparison with the other Mad2 proteins, pLV116 contains a cDNA insert that corresponds to the full-length *mad2* mRNA. Table 2 below shows the amino acid percent identity of all of the Mad2 homologs currently in the databases.

Table 2: Percent Amino Acid Sequence Identity Between Different Mad2 Homologs\*

Mad2 Homolog	<i>Arabidopsis</i>	Corn	Human	Mouse	Frog	Fission Yeast	Budding Yeast
<i>Arabidopsis</i>	-----						
Corn	81.3	-----					
Human	44.4	44.9	-----				
Mouse	45.4	45.9	94.6	-----			
Frog	43.3	42.9	78.3	77.3	-----		
Fission Yeast	40.4	41.9	43.8	43.8	46.3	-----	
Budding Yeast	38.3	38.8	39.3	39.3	39.8	45.4	-----

\* Comparisons were made with the MEGALIGN program at DNASTar (Madison, WI) using sequences present in Genbank. Abbreviations and accession numbers are as follows: *Arabidopsis*, *A. thaliana* Col-0 (this work); Corn, *Zea mays* (AAD30555); Human, *Homo sapiens* (NP\_002349); Mouse, *Mus musculus* (AAD09238); Frog, *Xenopus laevis*, (AAB41527); Fission yeast, *Schizosaccharomyces pombe* (AAB68597); Budding yeast, *Saccharomyces cerevisiae* (P40958).

Not unexpectedly, the sequence of the *Arabidopsis* Mad2 protein is more closely related to the corn Mad2, the only plant Mad2 homolog represented in the databases. The corn Mad2 is about 82% identical to the *Arabidopsis* Mad2. Figures 16A-B show yeast strains containing either pLV24 and pJG4-5, pEG202 and pLV116, or pLV24

and pLV116 on leucine drop-out plates and plates containing X-Gal, showing that only when both HopPsyA and Mad2 are present,  $\beta$ -galactosidase and *LEU2* activity are induced. It is important to note that the cDNA library that yielded *mad2* has been used for many different yeast 2-hybrid screens and a *mad2* clone has never been isolated from it before. Thus, the results shown in Figures 16A-B are unlikely to represent an artifact produced by the nature of the cDNA library. Moreover, different Mad2 homologs are known to interact with specific proteins and one of these homologs was isolated with a yeast 2-hybrid screen using a protein of the spindle checkpoint as bait (Kim et al., 1998). This is reassuring for two reasons. First, other Mad2 homologs do not appear to be nonspecifically “sticky” proteins. Second, they appear to modulate cellular processes through protein-protein interactions.

The above results are very promising, because Mad2 is a regulator controlling the transition from metaphase to anaphase during mitosis, a key step in the cell cycle of eukaryotes. The eukaryotic cell cycle is dependent on the completion of earlier events before another phase of the cell cycle can be initiated. For example, before mitosis can occur DNA replication has to be completed. Some of these dependencies in the cell cycle can be relieved by mutations and represent checkpoints that insure the cell cycle is proceeding normally (Hartwell and Weinert, 1989). In pioneering work, Hoyt et al. and Li and Murray independently discovered that there is a checkpoint in place in *Saccharomyces cerevisiae* to monitor whether the spindle assembly required for chromosome segregation is completed (Hoyt et al., 1991; Li and Murray, 1991). This so-called spindle checkpoint was discovered when the observation was made that wild-type yeast cells plated onto media containing drugs that disrupt microtubule polymerization arrested in mitosis, whereas certain mutants proceeded into anaphase. These initial reports identified 6 different nonessential genes that are involved in the spindle checkpoint: *bub1-3* named for budding uninhibited by benzimidazole and *mad1-3* for mitotic arrest deficient. Mutations in these genes ignore spindle assembly abnormalities and attempt mitosis regardless. In the years since, the spindle checkpoint has been shown to be conserved in other eukaryotes and many advances have occurred resulting in a better picture of what is taking place at the spindle checkpoint (Glotzer, 1996; Rudner and Murray, 1996).

Required for the transition from metaphase to anaphase (as well as other cell cycle transitions) is the ubiquitin proteolysis pathway. Proteins that inhibit entry into anaphase (e.g., Pds1 in *S. cerevisiae*) are tagged for degradation via the ubiquitin pathway by the anaphase-promoting complex (APC) (King et al., 1996).

5 Only when these proteins are degraded by the 26S proteasome are the cells allowed to cycle to anaphase. Although it is not well understood how the APC knows when to tag the anaphase inhibitors for degradation, there have been several important advances (Elledge, 1996; Elledge, 1998; Hardwick, 1998). The Mad2 protein and the Bub1 protein kinase have been shown to bind to kinetochores when these regions are  
10 not attached to microtubules (Chen et al., 1996; Li and Benezra, 1996; Taylor and McKeon, 1997; Yu et al., 1999). Thus, these proteins appear to somehow relay a signal that all of the chromosomes are not bound to spindle fibers ready to separate. Mad1 encodes a phosphoprotein, which becomes hyperphosphorylated when the spindle checkpoint is activated and the hyperphosphorylation of Mad1 is dependent  
15 on functional Bub1, Bub3, and Mad2 proteins (Hardwick and Murray, 1995). Another required protein in this checkpoint is Mps1, a protein kinase that activates the spindle checkpoint when overexpressed in a manner that is dependent on all of the Bub and Mad proteins, indicating that Mps1 acts very early in the spindle checkpoint (Hardwick et al., 1996).

20 Based on data from the different Mad2 homologs that have been studied, Mad2 appears to have a central role in the spindle checkpoint. Addition of Mad2 to *Xenopus* egg extracts results in inhibition of cyclin B degradation and mitotic arrest due to the inhibition of the ubiquitin ligase activity of the APC (Li et al., 1997). The overexpression of Mad2 from fission yeast causes mitotic arrest by activating the  
25 spindle checkpoint (He et al., 1997). Whereas, introducing anti-Mad2 antibodies into mammalian cell cultures causes early transition to anaphase in the absence of microtubule drugs, indicating that Mad2 is involved in the normal cell cycle. Several reports suggest that different Mad2 homologs directly interact with the APC (Li et al., 1997; Fang et al., 1998; Kallio et al., 1998). Another protein called Cdc20 in *S.*  
30 *cerevisiae* binds to the APC, is required for activation of the APC during certain cell cycles, and Mad2 binds to it (Hwang et al., 1998; Kim et al., 1998; Lorca et al., 1998; Wassmann and Benezra, 1998). The picture that is emerging from all of these exciting

findings is that Mad2 acts as an inhibitor of the APC, probably by binding to Cdc20. When Mad2 is not present, the Cdc20 binds to the APC, which activates the APC to degrade inhibitors of the transition to anaphase. Figure 12 shows a summary of the spindle checkpoint focusing on Mad2's involvement and using the names of the spindle checkpoint proteins from *S. cerevisiae*.

The plant spindle checkpoint: A possible target of bacterial pathogens. Many of the cell cycle proteins from animals have homologs in plants (Mironov et al., 1999). In fact, one of the early clues that there existed a spindle checkpoint was first made in plants. The observation noted was that chromosomes that lagged behind in their attachment to the spindle caused a delay in the transition to anaphase (Bajer and Mole-Bajer, 1956). Moreover, *mad2* has been recently isolated from corn and the Mad2 protein localization in plant cells undergoing mitosis is consistent with the localization of Mad2 in other systems (Yu et al., 1999). Based on a published meeting report, genes that encode components of the APC from *Arabidopsis* have been recently cloned (Inze et al., 1999). Thus, it appears that a functional spindle checkpoint probably is conserved in plants. The data presented above shows that the *P. syringae* HopPsyA protein interacts with the *Arabidopsis* Mad2 protein in the yeast 2-hybrid system.

It is possible that a pathogenic strategy of a bacterial plant pathogen is to alter the plant cell cycle. Duan et al. recently reported that *pthA*, a member of the *avrBs3* family of *avr* genes from *X. citri*, is expressed in citrus and causes cell enlargement and cell division, which may implicate the plant cell cycle (Duan et al., 1999). If HopPsyA does target Mad2, at least two possible benefits to pathogenicity can be envisioned. Since plant cells in mature leaves are quiescent, one benefit of delivering HopPsyA into these cells may be that it may trigger cell division through its interaction with Mad2. This is consistent with the observation that anti-Mad2 antibodies cause an early onset of anaphase in mammalian cells (Gorbsky et al., 1998). More plant cells near the pathogen may increase the nutrients available in the apoplast. A second possible benefit may occur if HopPsyA is delivered into plant cells actively dividing in young leaves. Delivery of HopPsyA into plant cells of these leaves may derail the spindle checkpoint through its interaction with Mad2. These cells would be prone to more mistakes segregating their chromosomes; in some cells

this would result in death and the cellular contents would ultimately leak into the apoplast providing nutrients for the pathogen.

**Example 8 - Cytotoxic Effects of HopPtoA and HopPsyA Expressed in Yeast**

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Both *hopPtoA* (SEQ. ID. No. 6) and *hopPsyA* (SEQ. ID. No. 35) were first cloned into pFLAG-CTC (Kodak) to generate an in-frame fusion with the FLAG epitope, which permitted monitoring of protein production with anti-FLAG monoclonal antibodies. The FLAG-tagged genes were then cloned under the control of the GAL1 promoter in the yeast shuttle vector p415GAL1 (Mumberg et al., 1994). These regulatable promoters of *Saccharomyces cerevisiae* allowed comparison of transcriptional activity and heterologous expression. The recombinant plasmids were transformed into uracil auxotrophic yeast strains FY833/4, selecting for growth on SC-Ura (synthetic complete medium lacking uracil) based on the presence of the URA3 gene on the plasmid. The transformants were then streaked onto SC-Ura medium plates containing either 2% galactose (which will induce expression of HopPsyA and HopPtoA) or 2% glucose. No growth was observed on the plates supplemented with 2% galactose. This effect was observed with repeated testing and was not observed with empty vector controls, with four other effectors similarly cloned into p415GAL1, or when raffinose was used instead of galactose. FLAG-tagged nontoxic Avr proteins were used to confirm that the genes were differentially expressed, as expected, on plates containing galactose. Importantly, the toxic effect with HopPsyA was observed when the encoding gene was recloned into p416GALS, which expresses foreign genes at a substantially lower level than p415GAL1.

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**References**

Each of the references cited herein or otherwise listed below are expressly incorporated by reference in their entirety into this specification.

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Although the invention has been described in detail for the purposes of illustration, it is understood that such detail is solely for that purpose, and variations can be made therein by those skilled in the art without departing from the spirit and scope of the invention which is defined by the following claims.